UNIFORM FEDERAL POLICY
QUALITY ASSURANCE PROJECT PLAN – DRAFT

Behr Dayton Thermal System VOC Plume Site Montgomery County, Dayton, Ohio

Remedial Investigation WA No. 227-RICO-B5FH7N/Contract No. EP-S5-06-01

Prepared for

September 2017

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Acronyms and Abbreviations

AB	ambient blank
AOC	area of concern
AS	air sparging
bgs	below ground surface
c	cancer
CC	continuing calibration
CCC	calibration check compounds
CCV	continuing calibration verification
CH2M	CH2M HILL
COC	constituents of concern
cis-1,2-DCE	cis-1,2-dichloroethene
DMP	Data Management Plan
DOH	Department of Health
DPT	direct-push technology
DQI	data quality indicator
DQO	data quality objective
EB	equipment blank
EDD	electronic data deliverable
EPA	U.S. Environmental Protection Agency
FOP	Field Operating Procedure
ft^2	square feet
FB	field blank
FD	field duplicate
GC/MS	gas chromatograph/mass spectrometry
GIS	geographic information system
GPR	ground-penetrating radar
GPS	global positioning system
HVAC	heating, ventilation, and air conditioning
IA	indoor air
IC	initial calibration
ICAP	inductively coupled argon plasma
ICP-MS	inductively coupled plasma-mass spectrometry
ICS	Interference check solutions

ICV	initial calibration verification
ID	identification
IDW	investigation-derived waste
LCS	laboratory control sample
LD	laboratory duplicate
MB	method blank
MCL	maximum contaminant level
MDL	method detection limit
MLE	multiple lines of evidence
$\mu g/m^3$	micrograms per cubic meter
mL	milliliter
MPC	measurement performance criteria
MS	matrix spike
MSD	matrix spike duplicate
NA	not applicable
nc	noncancer
Ohio EPA	Ohio Environmental Protection Agency
OSHA	Occupational Safety and Health Administration
PAL	project action limits
PARCCS	precision, accuracy, representativeness, comparability, completeness, and sensitivity
PCE	tetrachloroethene
%R	percent recovery
PID	photoionization detector
ppb	parts per billion
ppbV	parts per billion by volume
PPE	personal protective equipment
PRP	potentially responsible party
PRT	post-run tubing
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
QL	quantitation limit
RCRA	Resource Conservation and Recovery Act

RF	response factor
RI	remedial investigation
RL	reporting limit
RML	removal management level
ROW	right-of-way
RPD	relative percent difference
RRT	relative retention time
RSD	relative standard deviation
RSL	Regional Screening Level
SMP	Site Management Plan
SOP	standard operating procedure
SOW	Statement of Work
SPCC	system performance check compounds
SS	subslab soil vapor
SSC	site safety coordinator
SV	soil vapor
SVE	soil vapor extraction
SVOC	semivolatile organic compound
1,1,1-TCA	1,1,1-trichloroethane
TB	trip blank
TBD	to be determined
TCE	trichloroethene
TCLP	toxicity characteristic leaching procedure
TCRA	time-critical removal action
UFP	Uniform Federal Policy
USCS	Unified Soil Classification System
UST	underground storage tank
VC	vinyl chloride
VI	vapor intrusion
VISL	vapor intrusion screening level
VOC	volatile organic compound
WAM	work assignment manager

Worksheets #1 and #2—Title and Approval Page

Site Name/Project Name: Behr Dayton Thermal System VOC Plume Site

Revision Number: 0

Site Location: Montgomery County, Dayton, Ohio

Site Number/Code: N/A

Operable Unit: NA

Document Title: *Uniform Federal Policy Quality Assurance Project Plan—Behr Dayton Thermal System VOC Plume Site*

Lead Organization: U.S. Environmental Protection Agency (EPA)

Contractor Name: CH2M HILL (CH2M)

Contractor Number: EP-S5-06-01

Contract Title: Behr Dayton Thermal VOC Plume Site

Work Assignment Number: 227-RICO-B5FH189-RICO-B57N

Preparers' Name and Organizational Affiliation: Brett Fishwild/CH2M, Jaime Sutton/CH2M, Sally Scott/CH2M, Jenn Simms/CH2M

Preparer's Address, Telephone Number, and Email Address: 400 E Business Way, Suite 400, Cincinnati, Ohio 45241; (513) 587-7013; Brett.Fishwild@ch2m.com

Preparation Date (Day/Month/Year): 09/29/2017

1. Identify regulatory program:

   The Comprehensive Environmental Response, Compensation, and Liability Act of 1980, commonly known as Superfund

2. Identify approval entity: EPA Region 5
3. The Quality Assurance Project Plan (QAPP) is (select one): ☐Generic ☒Project-Specific
4. List dates of scoping sessions that were held: April 11 and 12, 2017
5. List dates and titles of QAPP documents written for previous site work, if applicable: Not applicable
6. List organizational partners (stakeholders) and connection with lead organization:

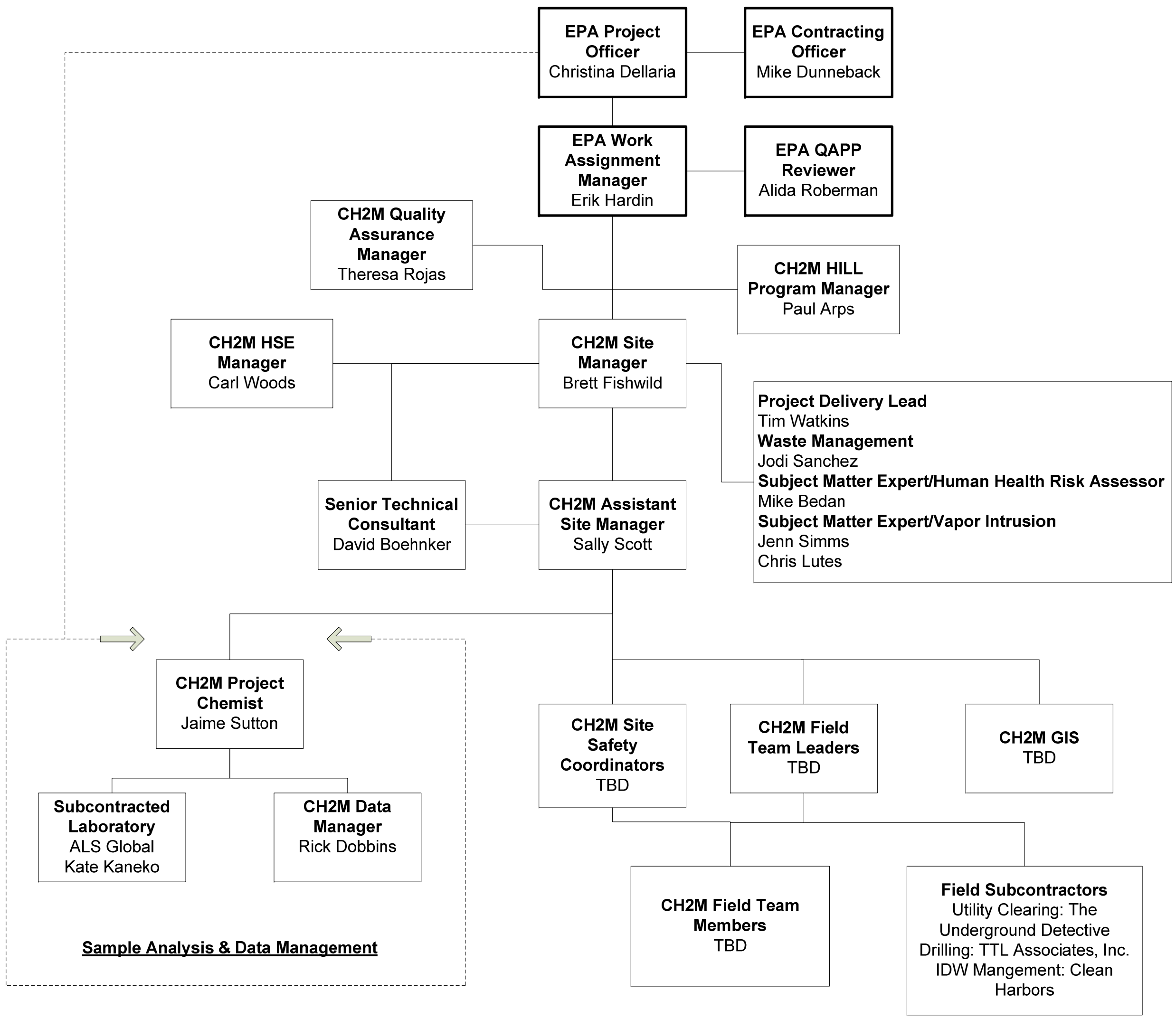
   EPA Region 5 (lead organization)
   Ohio Environmental Protection Agency (Ohio EPA) (State Agency)
   CH2M (contractor)

7. List data users:

   EPA, Ohio EPA, CH2M

Investigative Organization's Site Manager	[Date]	Brett Fishwild/CH2M
Investigative Organization's Site Program Quality Assurance (QA) Manager	[Date]	Theresa Rojas/CH2M
Lead Organization's Project Manager	[Date]	Erik Hardin/EPA
EPA Region 5 QAPP Reviewer	[Date]	Alida Roberman/EPA
Laboratory Director	[Date]	**TBD** Kelly Horiuchi/ALS Laboratory Director
Laboratory QA Manager	[Date]	**TBD** Chaney Humphrey/ALS Laboratory QA Manager

Worksheets #3 and #5—Project Organization and QAPP Distribution



QAPP Recipients	Title	Organization	Telephone Number	Fax Number	Email Address
Erik Hardin	Region 5 Work Assignment Manager	EPA	312-886-2402	n/a	Erik.Hardin@epa.gov
Alida Roberman	Region 5 QAPP Reviewer	EPA	312-886-7185	n/a	Roberman.alida@Epa.gov
Paul Arps	Remedial Action Contract Program Manager	CH2M	414-847-0259	414-454-8860	Paul.Arps@ch2m.com
Theresa Rojas	Program Quality Assurance Manager	CH2M	678-530-4297	770-604-9282	Theresa.Rojas@ch2m.com
Brett Fishwild	Site Manager/Project Quality Manager	CH2M	513-587-7013	n/a	Brett.Fishwild@ch2m.com
Sally Scott	Assistant Site Manager	CH2M	513-915-2676	314-421-3927	Sally.Scott@ch2m.com
David Boehnker	Senior Technical Consultant	CH2M	513-587-7116	n/a	David.Boehnker@ch2m.com
Tim Watkins	Project Delivery Lead	CH2M	517-668-6006	773-695-1341	Tim.Watkins@ch2m.com
Mike Bedan	Subject Matter Expert/Human Health Risk Assessor	CH2M	720-286-5333	720-286-9837	Mike.Bedan@ch2m.com
Chris Lutes	Subject Matter Expert/Vapor Intrusion	CH2M	919-903-9921	n/a	Christopher.Lutes@ch2m.com
Jenn Simms	Subject Matter Expert/Vapor Intrusion	CH2M	215-640-9071	215-640-9271	Jennifer.Simms@ch2m.com
Jaime Sutton	Project Chemist	CH2M	414-847-0337	414-454-8767	Jaime.Sutton@ch2m.com
Jodi Sanchez	Waste Manager	CH2M	530-229-3443	530-339-3443	Jodi.Sanchez@ch2m.com
Rick Dobbins	Database Manager	CH2M	352-384-7049	n/a	Rick.Dobbins@ch2m.com
Kate Kaneko	Project Manager Subcontracted Laboratory	ALS Global	805-577-2089	805-526-7270	Kate.Kaneko@ALSGlobal.com

Worksheets #4, #7, and #8—Personnel Qualifications and Signoff Sheet

Name	Title	Organizational Affiliation	Responsibilities	Education and Experience Qualifications
Erik Hardin	Region 5 Work Assignment Manager	EPA	Overall responsibility for all phases of work, review, and approval.	
Alida Roberman	Region 5 QAPP Reviewer	EPA	QAPP review and approval.	
Paul Arps	Program Manager	CH2M	Principal point of contact for the EPA contracting officer and project officer. Directs the creation and/or implementation of program policies. Selects the program QA manager with endorsement by the business group federal sector quality manager. Reviews budget, schedule, and performance reports. Reviews corrective actions and lessons learned to assess the effectiveness of resolutions. Allocates resources for quality management.	B.S., Chemistry, 17 years of experience
Theresa Rojas	Program QA Manager	CH2M	Accountable for the overall QA of the program. Approves and charters project quality manager. Evaluates project quality requirements and supports implementation to meet quality requirements. Resolves disputes concerning quality through discussion and negotiation.	B.S., Chemistry, 29 years of experience
Brett Fishwild	Site Manager	CH2M	Responsible for executing the phases of the work assignment and for efficiently applying the full resources of the project team. Responsible for the technical, financial, administrative, and client-related aspects of the project and the project team. Plans the execution of the work assignment and identifies necessary staff. Organizes, directs, and manages personnel and resources. Communicates with the EPA work assignment manager (WAM). Responds to and implements corrective actions.	M.S., Geological Sciences, B.S., Geological Sciences, 19 years of experience

Name	Title	Organizational Affiliation	Responsibilities	Education and Experience Qualifications
Sally Scott	Assistant Site Manager	CH2M	Assists the site manager with administrative, decision, and approvals. Responsible for the overall technical approach of the project and coordinating deliverable reviews. Provides the project-specific technology function and is involved throughout the life of the project. Supports the quality and technical accuracy of the work. Monitors the scope, quality, and completeness through consultation and review of project deliverables.	B.S., Geology, 7 years of experience
Mike Bedan	Subject Matter Expert/Human Health Risk Assessor	CH2M	Provides technical human health risk assessment expertise and develops site-specific goals for the site including vapor intrusion (VI).	M.S., Environmental Science, B.S., Chemistry, 25 years of experience
Chris Lutes	Subject Matter Expert/VI	CH2M	Provides technical VI investigation expertise and develops site-specific goals for the site.	M.S., Environmental Science and Engineering, B.S. Chemistry, 25 years of experience
David Boehnker	Senior Technical Consultant	CH2M	Provides technical expertise and develops site-specific goals for the site.	B.S., Geology, 35 years of experience
Tim Watkins	Project Delivery Lead	CH2M	Assists the site manager on financial management of the project.	M.S., Fisheries and Wildlife, B.S., Biology, 26 years of experience
Carl Woods	Health and Safety Operations Manager	CH2M	Provides support and assistance for health and safety requirements and management.	M.S., Environmental Safety Management, B.A., General Studies, 11 years of experience
Jaime Sutton	Project Chemist	CH2M	Assists in QAPP preparation, coordinates laboratory subcontractors, and performs oversight of laboratory and data validation, performs data evaluation.	B.S., Geography, 3 years of experience
TBD	Field Team Leader/Field Quality Manager/ Site Safety Coordinator	CH2M	Documents and conveys progress of field activities, including adherence and any deviations from the QAPP; communication with task lead and project chemist, and others as directed by them; directs CH2M field support staff and contractors; provides daily safety briefings and directs onsite safety activities.	
Rick Dobbins	Database Manager	CH2M	Sets up the project data management system, performs data conversion, QC and database maintenance, and prepares data exports (tables, electronic data deliverables [EDDs]).	B.S., Chemistry, 26 years of experience
Kate Kaneko	Laboratory Project Manager	ALS Global	Coordinates laboratory analysis and reporting, and maintains communication with the project chemist.	B.A., Chemistry, 8 years' analytical experience, 20 years PM experience

Special Training Requirements

Project Function	Specialized Training Title or Description of Course	Training Provider	Training Date	Personnel/Groups Receiving Training	Personnel Titles/ Organizational Affiliation	Location of Training Records/Certificates
Field Activities	Hazardous waste operations 40-hour training; 8-hour refresher	Registered training organization	Annually	All field staff	Field team staff	CH2M Human Resources Department
Field Activities	Cardiopulmonary resuscitation (CPR) and first-aid	Registered training organization	Every 2 years	SSC	SSC from CH2M	CH2M Human Resources Department
Field Activities	Site Safety Coordinator (SSC)–Hazardous Waste	Registered training organization	Every 3 years	SSC	SSC from CH2M	CH2M Human Resources Department
Health and Safety	Health and safety plan	CH2M	Various	All field personnel and subcontracted project personnel working in the field	All field personnel from CH2M and subcontracted personnel	Signoff sheet at the end of the health and safety plan

Signoff Sheet

Organization: EPA

Project Personnel	Title	Telephone Number	Signature	Date
Erik Hardin	Region 5 Work Assignment Manager	312-886-2402		
Alida Roberman	Region 5 QAPP Reviewer	312-886-7185		

Organization: CH2M—To be signed once Uniform Federal Policy (UFP)-QAPP is approved by Lead organization.

Project Personnel	Title	Telephone Number	Signature	Date
Paul Arps	Program Manager	262-349-4180		
Theresa Rojas	Program QA Manager	678-530-4297		
Brett Fishwild	Site Manager	513-587-7013		
Sally Scott	Assistant Site Manager	513-915-2676		
David Boehnker	Senior Technical Consultant	513-587-7116		
Mike Bedan	Subject Matter Expert/Human Health Risk Assessor	720-286-5333		
Chris Lutes	Subject Matter Expert/VI	919-903-9921		

Organization: CH2M—To be signed once Uniform Federal Policy (UFP)-QAPP is approved by Lead organization.

Project Personnel	Title	Telephone Number	Signature	Date
Jenn Simms	Subject Matter Expert/VI	215-640-9071		
Jodi Sanchez	Waste Manager	530-229-3443		
Tim Watkins	Project Delivery Lead	517-668-6006		
Carl Woods	Health and Safety Operations Manager	513-889-5771		
Jaime Sutton	Project Chemist	414-847-0337		

Worksheet #6—Communication Pathways

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathways, etc.)
Communication with CH2M program manager	EPA project officer	Christina Dellaria	312-886-3854	Provides administrative direction to CH2M program manager and project team, authorizes changes to plan, and can stop work, if needed.
Communication with CH2M contract manager	EPA contracting officer	Mike Dunneback	312-886-7523	Provides administrative direction to CH2M contracts manager.
Communication with CH2M site manager	EPA WAM	Erik Hardin	312-886-2402	Serves as primary point of contact for EPA, and provides approval of technical direction to CH2M site manager.
Communication with EPA program officer and Contracting Officer	CH2M program manager	Paul Arps	262-349-4180	Receives contractual direction from EPA program officer and contracting officer, and notifies EPA of contractual deviations (changes in scope of work, budget, or schedule) by email or letter.
Point of contact with EPA work assignment manager	CH2M site manager	Brett Fishwild	513-587-7013	Materials and information about the project will be forwarded to EPA WAM by site manager.
Manage technical project phases	CH2M assistant site manager	Sally Scott	513-915-2676	Notifies site manager of remedial investigation-related problems by next business day. Serious issues will also be reported to program quality manager.
Field staff discussion and inquiry	CH2M Field Team Leader	TBD	TBD	Serve as a primary point of contact for field team before, during, and after the investigation; communicates back to the site manager, quality manager, and project chemist, as needed. Communication by phone as needed with field staff during field sampling events, followed up with email to document decisions and actions.
Health and safety	CH2M SSC(s)	TBD	TBD	Responsible for the adherence of team members to the site safety requirements described in the health and safety plan. Will report health and safety incidents and near misses to the site manager and health and safety operations manager.
QAPP changes in the field	CH2M field team leaders	TBD	TBD	The field team leader will notify the site manager by phone and email of changes to the QAPP made in the field and the reasons within 24 hours. Documentation of deviations from the work plan will be kept in the field logbook; deviations made only with the approval of the contractor site manager. The site manager will advise Erik Hardin of changes, and QAPP changes will be reviewed and approved by the same people that approved the final QAPP document.
Daily field progress reports	CH2M field team leaders	TBD	TBD	Email or fax daily field progress reports to site manager.
Field corrective actions	CH2M field team leaders	TBD	TBD	The need for corrective action for field issues will be determined by the field team leader. The site manager will ensure QAPP requirements are met by field staff. The field team leader will notify the site manager of needed field corrective actions. The site manager will have 24 hours to respond to the request for field corrective action.

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathways, etc.)
Reporting laboratory data quality issues	Laboratory Project Manager	Kate Kaneko	805-577-2089	QA/QC issues with field samples will be reported to the project chemist immediately.
Analytical corrective actions	Project chemist	Jaime Sutton	414-847-0337	The need for corrective action by the analytical laboratory will be determined by the project chemist. The project chemist will ensure QAPP requirements are met by the laboratory. No analytical data can be released until data are reviewed for completeness and conformance to analytical guidelines by the project chemist. The project chemist will review data as soon as possible upon receipt from the validator.
Release of analytical data	Laboratory Project Manager	Kate Kaneko	805-577-2089	No analytical data can be released to CH2M and EPA until they have been reviewed by the laboratory. No final data can be released to CH2M until validation is completed and the laboratory has approved the release.
QAPP amendments	Region 5 WAM and QAPP Reviewer	Erik Hardin Alida Roberman	312-886-2402 312-886-7185	Major changes to the QAPP must be reviewed and approved by the same people that reviewed and approved the final QAPP before the changes can be implemented.

Worksheet #9—Project Planning Session Summary

Site Name:	Behr Dayton Thermal VOC Plume Site
Project Name and Site Location:	Behr Dayton Thermal VOC Plume Site, Montgomery County, Ohio
Projected Date(s) of Sampling:	August 2017 through February 2018
Site Manager:	Brett Fishwild

Date of Session: April 11 and 12, 2017

Scoping Session Purpose: Develop and obtain team endorsement on the overall strategy and activities to be completed for sampling and analysis at the Behr Dayton Thermal VOC Plume Site.

Name	Title/Role	Affiliation	Phone #	Email Address
Erik Hardin	Remedial Project Manager/WAM	EPA	(312)-886-2402	erik.hardin@epa.gov
Leslie Williams	Remedial Project Manager	Ohio EPA	(937) 285-6054	leslie.williams@epa.ohio.gov
Chuck Mellon	Senior Site Coordinator	Ohio EPA	(937) 285-6056	Charles.mellon@epa.ohio.gov
Brett Fishwild	Site Manager	CH2M	(937) 220-2955	Brett.Fishwild@ch2m.com
Jenn Simms	VI Subject Matter Expert	CH2M	(215) 640-9071	Jennifer.Simms@ch2m.com
Sally Scott	Assistant Site Manager	CH2M	(513) 915-2676	Sally.Scott@ch2m.com

Decisions/Discussion Items

EPA presented the remedial history of the site and the expectations of the project. A site walk was completed to visually inspect the site and subject properties to be sampled.

During the scoping session, the following scope of work for the VI sampling was agreed upon:

Site-Specific Plans

- Site Management Plan (SMP): Minimal changes will be completed to the existing SMP, focusing on the offsite areas in general.
- QAPP: A new UFP-QAPP (this document) will be completed covering the proposed VI investigation. EPA and State of Ohio screening levels will be included and used for screening of the analytical data. The Ohio EPA will not conduct a formal review of the QAPP, but will conduct a 5- to 10-day summary review and informally provide technical review comments via email. A Draft QAPP will initially be prepared, followed by a Final QAPP incorporating the Ohio EPA comments and laboratory standard operating procedures (SOPs).

- Data Management Plan: A stand-alone data management plan will be created to describe how the VI sampling data from this project, and other VI projects at this same site conducted by a variety of parties, will be maintained. This document will be created after submittal of the QAPP.
- Health and Safety Plan (HASP): Minor updates will be completed to the existing HASP, mainly to include new activities not previously completed (i.e., VI sampling).

Community Relations

- All public meetings should be costed under Task 13 – Post-RI/FS Support.

Field Implementation

- CH2M will complete one round of mailings to up to 300 properties for the purpose of obtaining access agreements. EPA will then send postcards to landowners who do not respond to the initial mailing. Finally, CH2M will conduct one round of in-person attempts at residential properties in which the landowners have not yet responded. It is assumed that access will not be granted for the Behr facility but will be granted for the Aramark and Gem City facilities.
- Sampling will be conducted as follows:
  - **Warehouses** – Indoor air (IA) samples will be collected in offices, and subslab soil vapor (SS) samples will be collected throughout the remainder of the buildings.
  - **Unoccupied Buildings** – SS samples will be collected at buildings that appear serviceable and could be rented/used soon, but have their heating, ventilation, and air conditioning (HVAC) system off.
  - **Abandoned/Unoccupied Buildings** – No samples will be collected at buildings which appear unserviceable and abandoned, or warehouses that cannot be used for occupancy.
  - **Buildings with Use of Site-Specific Chemicals** – If tetrachloroethene (PCE)/trichloroethene (TCE) is routinely used in a building, an attempt will be made to see if they are following Occupational Safety and Health Administration (OSHA) regulations for chemical monitoring. Buildings with regular, documented users of PCE/TCE will not be sampled. Buildings with volatile organic compound (VOC) indoor sources, which may include some small amount of PCE/TCE will be sampled for SS only.
- Number of Samples - CH2M will utilize the geographic information system (GIS) data obtained from Montgomery County to list the square footage of each building in the sampling area as defined by the VI screening level (VISL) in groundwater as presented in the Draft Remedial Investigation Report. From that list, CH2M will determine the number of assumed samples based on size and best management practices. However, exterior soil vapor sampling will be performed instead of IA and SS sampling in the area northeast of the Behr and Gem City facilities as well as the residential complex east of Gem City, where groundwater concentrations are relatively lower.
- Sampling Events - Any property exceeding removal management levels (RMLs) for both IA and SS will not be resampled by EPA and the RPM will take these results to the Removal Program. Any property that does not exceed RMLs will be sampled a second time approximately 6 months from the first event. CH2M will assume a percentage of properties to be determined at a later date will be resampled.
- Building Surveys – The building surveys will include checking for indoor VOC sources with a handheld photoionization detector (PID) (initial visit to the property).

- Analytes - For evaluation purposes, CH2M will report analytical results for site-specific constituents of concern (COCs) and applicable degradation products. However, the entire TO-15 analytical report will be submitted to EPA for its dispersal to the public as EPA deems appropriate.

Sample Analysis

- The WAM confirmed that subcontracted analytical laboratories should be used for the VI sampling due to the number of samples and schedule for the project.
- For residential locations, all IA and SS samples will be analyzed. For commercial properties, the IA samples will be held until the SS results are received. To expedite analysis, SS samples will be submitted for 7-day turnaround times.

Data Evaluation

- The following assumptions will be used to cost the VI database activities:
  - Analytical laboratory EDDS will include TO-15 air data. Validated results will be uploaded to the EQuIS database (or one upload if using non-validated results).
  - Each upload will also include sample location coordinates, address and county tax parcel ID information, free hand notes (e.g., “this is a duplex with slab-on-grade construction”), and several fields including location descriptors such as residential/commercial, owned/rented, occupied/rented, and system installation.
  - VI samples will be collected from approximately 200 structures during the first event followed by a smaller percentage in fall/winter of 2017.
  - VI samples will be collected from approximately 200 structures per year for the next 2 years by a third-party and CH2M will manage these data using the developed site database.
  - An EDD format will be prepared by CH2M and provided for use by the third-party.
- Reporting and communication of results:
  - CH2M will notify the WAM within 48 hours of receipt of preliminary results if there is an RML exceedance.
  - CH2M will create and send to the WAM a working table of results showing the site-specific COCs compared to VISLs and RMLs.
  - Data validation will not be performed on the preliminary results.
  - CH2M will compile and send letters, upon EPA review and approval, to property owners that include the final analytical results for each sampling event.

Follow-up Task

CH2M will submit a work plan to EPA to define the activities, schedule, and budget for completing the field sampling and reporting at the site. This QAPP will be prepared in parallel with EPA’s review of the work plan to expedite completion of the site investigations.

NOTE – the outcome of this scoping session was superseded by subsequent meetings and the revised Statements of Work issued by EPA after this meeting.

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Worksheet #9-1—Project Planning Session Summary

Site Name:	Behr Dayton Thermal VOC Plume Site
Project Name and Site Location:	Behr Dayton Thermal VOC Plume Site, Montgomery County, Ohio
Projected Date(s) of Sampling:	August 2017 through February 2018
Site Manager:	Brett Fishwild

Date of Session: July 12, 2017 and August 8, 2017

Scoping Session Purpose: Revision Number Three to Statement of Work for Work Assignment 227.

Name	Title/Role	Affiliation	Phone #	Email Address
Erik Hardin	Remedial Project Manager/WAM	EPA	(312)-886-2402	erik.hardin@epa.gov
Brett Fishwild	Site Manager	CH2M	(937) 220-2955	Brett.Fishwild@ch2m.com

Decisions/Discussion Items

On July 12, 2017, EPA issued Revision Number 3 to the Statement of Work (SOW) for Work Assignment 227. This revised SOW requests that CH2M assume that only 15 structures, to be chosen by EPA, require sampling for VI by CH2M. Additionally, the revised SOW requests that CH2M assume only one-half week of exterior soil vapor sampling as opposed to the original 32 locations that would require 7 days of sampling.

The potentially responsible parties (PRPs) subsequent held a teleconference with EPA on August 8, 2017, stating that they would not conduct any sampling northeast of the Behr facility, and that the PRPs would conduct VI sampling in the remainder of the AOC area. This sampling will be completed separately from the work described in this QAPP, and will be described in a PRP created work plan that will be completed after submittal of this QAPP. After that teleconference, the WAM requested from the site manager via telephone that CH2M assume completing up to the original 32 sampling locations for exterior soil vapor with the assumed 7 sampling days.

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Worksheet #10—Conceptual Site Model

The Problem to be Addressed by the Project

The purpose of this project is to assess the potential presence and extent of a soil vapor plume northeast and east of the Behr facility (Figure 1) and assess the potential for currently complete and significant VI pathways (resulting in indoor air COC concentrations that exceed regulatory target levels) at particular occupied buildings selected by EPA located within the Behr Dayton Thermal VOC groundwater VISL plume that have not yet been sampled by others (Figure 2). The EPA selected buildings are expected to potentially include some buildings south or southwest of the Behr facility.

Site Description

The site includes the three facilities (Behr, Gem City, and Aramark) that are located within Dayton, Ohio, approximately 1.5 to 2 miles north of downtown Dayton in an area of mixed industrial, commercial, and residential land uses (Figure 1). The site boundary is defined by the extent of the groundwater plume that is currently identified east of Ohio State Route 202 (Troy Street), extending to the boundaries of the Great Miami River to the north and west, the confluence of the Great Miami and Mad Rivers to the southwest, and the Mad River to the south. The City of Dayton has two well fields in the vicinity of the site: the Dayton Miami South Well Field, located within 1 mile to the to the north across the Great Miami River; and the Dayton Mad River Well Field, located approximately within 3 miles to the east across the Mad River.

The site extends to areas where hazardous substances, pollutants, or contaminants from those three facilities or from former operations at those three facilities have or may have come to be located. The lateral migration of contamination is primarily affected by groundwater flow to the south toward the confluence of the Great Miami and Mad Rivers and to the north toward the Dayton Miami South Well Field. Under the Behr and Gem City facilities, a groundwater divide area is characterized by a flat hydraulic gradient where lateral migration is slow. The southern portion of the plume is the most aerially extensive and contains the highest concentrations while the northeastern portion of the plume is much smaller and exhibits concentrations generally less than 100 micrograms per liter (μg/L).

Behr contains approximately 60 acres of buildings, parking areas, and outdoor storage areas. Aramark is an industrial laundry facility containing a building and parking lot on approximately 3 acres of land. Gem City repackages chemicals and is a bulk chemical distributor. Its facility encompasses 8 acres of a mix of indoor and outdoor chemical storage areas. The topography of the area is generally flat with slight grades and little relief. Two major rivers are located in the vicinity of the site: the Great Miami River and the Mad River. The Great Miami River flows generally in a southerly direction and is located north, west, and south of the site, and the Mad River flows to the west and is located east and south of the site. The Great Miami River is the dominant river in the Dayton area, and the Mad River joins the Great Miami River, as a tributary, south of the site, forming a U-shaped area around the site.

Facility Descriptions, Source Characterization, and Remedial Measures

Dissolved chlorinated VOC constituents (plume) have been detected in groundwater. The extent of the site plume includes comingling of releases documented from Behr, Aramark, and Gem City (EPA, 2008). Although the plume is primarily associated with these three facilities (Behr, Gem City, and Aramark), EPA identified other facilities in the area with documented use or discharge of chlorinated VOCs as part of the HRS evaluation.

A detailed description of the documented releases related to the site plume are included in the Remedial Investigation (RI) and is summarized in the following sections (CH2M, 2016).

Behr

Behr contains two main structures that occupy most of the central and southern sides of the property. The current buildings at Behr were constructed in 1920, 1969, and 1992. Chrysler manufactured air conditioning equipment at Behr. During Chrysler's ownership, hazardous substances, including PCE and TCE, were released into the subsurface at Behr. Historical manufacturing processes at Behr used industrial solvent cleaners, including PCE, TCE, 1,1,1-trichloroethane (1,1,1-TCA), and sulfuric acid (Ohio Department of Health (DOH), 2014). Behr conducted a soil investigation that identified TCE and PCE contamination (EPA, 2008). Chlorinated VOCs, including TCE, PCE, and 1,1,1-TCA, have been detected in groundwater samples collected at the site. Since the early 1990s, Chrysler documented groundwater contamination beneath the facility. In the early 2000s, Chrysler began to design, install, and later operate onsite and offsite groundwater remediation systems (EPA, 2008). Chrysler installed an additional soil vapor extraction (SVE) system in May 2008, under the 2006 area of concern (AOC), one block south of Behr (the 2008 SVE system). The 2008 SVE system applied a vacuum to an area of the subsurface between 5 and 20 feet below ground surface (bgs) to remove vapor-phase contaminants (Ohio DOH, 2014). After initial operation of the 2008 SVE system, Ohio DOH reported that TCE levels were significantly reduced in samples from both indoor air and in the soil vapor underneath nearby residential homes. The 2008 SVE began operation in the end of July 2008 and is still operating (Ohio DOH, 2014).

Aramark

Aramark Uniform & Career Apparel, Inc. operates an industrial laundry, providing uniform cleaning services at its facility at 1200 Webster Street Dayton, Ohio 45404. Aramark discontinued use of PCE in 1987; dry cleaning solvents and equipment, including a PCE storage tank located outside of the northeast corner of the building, were permanently removed. In December 1991, Aramark removed two underground storage tanks (USTs) containing gasoline and fuel oil. PCE and TCE concentrations were observed in soil and groundwater within the footprint of the former USTs and downgradient of the facility.

To reduce the potential for additional soil contamination leaching to the underlying groundwater, Aramark implemented a dual SVE/air sparging (AS) system consisting of five SVE wells and six AS wells at the site. Aramark operated the system from September 25, 1996, until 2003 (EPA, 2008).

Gem City

Gem City, located at 1287 Air City Drive, is a privately held company incorporated in Ohio in 1957. It manufactures custom molded urethane products, and is a bulk chemical distribution and prepackaging facility that has been in operation since 1969. EPA environmental investigations at Gem City have identified compounds in soil that include methylene chloride, PCE, TCE, 1,1,1-TCA, isopropyl alcohol, acetone, toluene, xylene, and methyl ethyl ketone (EPA, 2008). Ohio EPA became aware of the contamination in groundwater at Gem City in 1989 during a regional investigation of the sources of VOC contamination in the Dayton Mad River Well Field.

Gem City installed a soil extraction system consisting of five SVE wells and a groundwater pump and treat system consisting of an extraction well and an air stripper at its facility without Ohio EPA oversight or formal approval (EPA, 2008). The SVE system was operational for 2 years and removed an estimated 1,100 pounds of VOCs (EPA, 2008).

Vapor Intrusion Investigation and Mitigation Overview

The assessment and mitigation of the VI pathway are currently being conducted as part of the removal action separately from the investigation for which this QAPP is being written. However, the VI investigation and removal action conducted between 2006 and 2014 are summarized in the following paragraphs, including installation of vapor intrusion mitigation systems (VIMS), also referred to as vapor abatement systems.

In 2002, DaimlerChrysler notified Ohio EPA that the VOC plume from Behr was migrating offsite in the groundwater at levels that required additional investigation to assess the potential VI risk to area residents due to VI. By 2006, the investigation identified concentrations of chlorinated VOCs in groundwater migrating offsite from the Behr facility that could migrate from the groundwater and travel through the vadose zone as soil vapor and into homes and businesses in the neighborhood south of the Behr Dayton facility. In October 2006, Ohio EPA sampled the soil vapor in the residential area south of Behr, which identified contaminant concentrations that significantly exceeded the EPA OSWER screening levels current at that time (EPA, 2002) for chlorinated VOCs in shallow soil vapor.

Based on the results of the soil vapor investigation south of Behr, Ohio EPA formally requested assistance from the EPA Emergency Response Branch on November 6, 2006, to conduct a time-critical VI investigation at the site (Ohio DOH 2014). EPA initiated an additional VI investigation by sampling subslab soil vapor and indoor air in the neighborhood south of Behr in November 2006. As a result, on December 19, 2006 an Administrative Order on Consent was signed by EPA and Chrysler to establish a scope of work for a time critical removal action (TCRA) to install subslab VIMS in residences that had indoor air TCE concentrations greater than 0.4 parts per billion by volume (ppbV). As indoor air and subslab soil vapor sampling continued in 2007 and 2008, the VI investigation area increased to include most of the neighborhood south of Behr out to the Great Miami River.

Starting in November 2007 through 2009, EPA led the removal action in many residential buildings (homes), along with commercial and industrial buildings, in proximity to Behr and downgradient of Behr. In 2009, after Chrysler filed for bankruptcy and stopped work, EPA issued a unilateral order to Behr Dayton Thermal Products LLC to continue the removal action, which is ongoing under the oversight of EPA. These activities involve obtaining access agreements for sampling and installation of VIMS, additional baseline indoor air and subslab soil vapor sampling, and installation, inspection, and maintenance of VIMS.

In addition, as discussed in **Worksheet #10**, Chrysler installed an SVE system in May 2008 in the neighborhood just downgradient (south) of Behr. TCE levels were significantly reduced in both indoor air and in the soil vapor samples of nearby residential homes as reported by Ohio DOH (Ohio DOH, 2014). The SVE has been operating since the end of July 2008 (Ohio DOH, 2014).

Sampling Rational

Two geographically separate investigation programs will be performed at the site for this project as follows:

- **Soil vapor plume delineation northeast and east of the Behr facility** - Exterior soil vapor sampling will be performed in the groundwater VISL plume area north and east of the Behr facility where groundwater concentrations are relatively lower (generally less than 100 μg/L) to delineate the soil vapor plume (TCE, PCE, cis-1,2-dichloroethene [cis-1,2-DCE], 1,1,1-TCA, and/or vinyl chloride [VC]) as described in **Worksheet #17**. Temporary exterior soil vapor probes will be installed and sampled at up to 32 locations (Figure 2). The deep soil vapor probe screens will be placed approximately 3 to 5 feet above the groundwater table which will be determined from historical groundwater elevation information, gauging nearby monitoring wells, and up to 10 soil borings. Additionally, dual-depth probes, with the shallow screen approximately 5 to 6 feet bgs, will be installed and sampled at four of the up to 32 locations to assess the vertical profile of TCE, PCE, and 1,1,1-TCA in soil vapor. The soil vapor samples will be analyzed in the field with a HAPSITE GC/MS for PCE, TCE, cis-1,2-DCE, 1,1,1-TCA, and VC, and 10 percent of the samples will be submitted for laboratory analysis of the site-specific COC list described in **Worksheets #15-1** and #15-2by EPA Method TO-15.

- **Interior VI sampling south and west of the Behr facility** - The potential for complete and significant VI pathways will be assessed at occupied buildings selected by EPA that are expected to include some buildings have not been previously sampled in the groundwater VISL plume area south and west of the Behr facility. The interior VI sampling will include performing building surveys and collecting interior VI samples (indoor air, and subslab soil vapor and/or crawlspace air) and outdoor air samples as described in **Worksheet #17**. The interior VI samples will be submitted for laboratory analysis of the site-specific COC list described in **Worksheets #15-1 and #15-2** by EPA Method TO-15 SIM. It is assumed that interior VI sampling will be performed at up to 15 buildings for planning purposes. A second round of interior VI sampling will be performed approximately 6 months after Round 1 at buildings where the first round of samples had measured concentrations below the EPA RMLs. It is assumed that a second round of interior VI sampling will be performed at eight of the 15 buildings for planning purposes.

Project Decision Conditions ("If…, then…" statements)

Soil Vapor Plume Delineation Northeast and East of the Behr Facility

- If there is a deep soil vapor plume (PCE, TCE, cis-1,2-DCE, 1,1,1-TCA, and VC) identified northeast and/or east of the Behr facility (where the groundwater line of evidence already suggests this may be possible), and there are areas of the soil vapor plume that exceed VISLs that are located within 100 feet of occupied buildings, then additional VI investigation may be necessary at those buildings but performing an extensive study of numerous buildings in that area is outside of the scope of work included in this QAPP.
- If the vertical profiles of PCE, TCE, cis-1,2-DCE, 1,1,1-TCA, and VC concentrations observed in the four dual-depth soil vapor probes demonstrate that deep soil gas concentrations may exceed VISLs, but shallow soil gas concentrations do not, then this line of evidence will be considered when evaluating the soil vapor plume, especially in the case of buildings without deep basements. Additional external shallow soil vapor sampling may be advisable instead of interior VI sampling at buildings as the next step in the VI investigation in this area, but both are outside of the scope of work included in this QAPP. Results from the dual-depth soil vapor probes will also be used to evaluate the potential for vadose zone VOC sources.
- If there is a soil vapor plume (PCE, TCE, cis-1,2-DCE, 1,1,1-TCA, and VC) identified northeast and/or east of the Behr facility, and it is not fully delineated laterally to VISLs by the up to 32 exterior soil vapor probe locations, then additional soil vapor sampling may be necessary to fully delineate the plume but is outside of the scope of work included in this QAPP.

Interior VI Sampling at EPA Selected Buildings Expected to include some South and West of the Behr Facility

- If there are buildings identified from the interior VI sampling with currently complete and significant VI pathways based on multiple lines of evidence (MLE) (refer to **Worksheet #11**) causing indoor air concentrations of site-specific COCs to exceed the RMLs (on an individual or cumulative basis), then

EPA will refer those buildings primarily to the TCRA and if needed, secondarily to the Removal Management Program.

- If there are buildings identified from the interior VI sampling with indoor air concentrations of site-specific COCs below the RMLs, or indoor air concentrations of site-specific COCs above the RMLs but not due to VI based on MLE, then one additional round of interior VI sampling will be performed at these buildings six months later.
- If there are buildings with currently complete and significant VI pathways based on MLE causing indoor air concentrations of site-specific COCs to exceed the VISLs but not RMLs identified after two rounds of interior VI sampling, then EPA will refer those buildings primarily to the current TCRA.
- If there are buildings with currently incomplete and/or insignificant VI pathways, but with the potential for future complete and significant VI pathways identified based on MLE after two rounds of interior VI sampling, then EPA will refer those buildings to the long-term monitoring plan for the sitewide final remedy.
- If there are buildings with the potential for current and/or future complete and significant VI pathways but were not sampled due to lack of access, then EPA will refer those buildings to the long-term monitoring plan for the site-wide final remedy.

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Worksheet #11—Project/Data Quality Objectives

Table 11-1. Data Quality Objectives

DQO #	Step 1: Statement of Problem	Step 2: Identify Goals of the Study	Step 3: Identify Information Inputs	Step 4: Define Boundary Studies	Step 5: Develop Analytical Approach	Step 6: Specify performance or acceptance criteria	Step 7: Develop plan for obtaining data
1	The potential presence of a soil vapor plume has not been evaluated in the groundwater VISL plume area northeast and east of the Behr facility.	The goal is to delineate the PCE, TCE, cis-1,2-DCE, 1,1,1-TCA, and VC deep soil vapor plume(s) in the groundwater VISL plume area northeast and east of the Behr facility. Additionally, the vertical profile of site-specific PCE, TCE, cis-1,2-DCE, 1,1,1-TCA, and VC in soil vapor will be assessed at selected locations.	Hydrogeologic information from the Remedial Investigation Report. Soil borings at up to 10 locations to assess the soil type and depth to groundwater which will assist with screen depth selection for the soil vapor probes. Real-time soil vapor sampling results from the field HAPSITE device for PCE, TCE, cis-1,2-DCE, 1,1,1-TCA, and VC from up to 32 temporary soil vapor probes. Dual-depth soil vapor sampling results for PCE, TCE, cis-1,2-DCE, 1,1,1-TCA, and VC from 4 of the up to 32 probes. Confirmation sampling results from 10 percent of the samples for site-specific COCs. EPA and Ohio EPA VISLs and EPA RMLs.	The groundwater VISL plume area northeast and east of the Behr facility.	The soil vapor samples will be analyzed for PCE, TCE, cis-1,2-DCE, 1,1,1-TCA, and VC using a HAPSITE. Confirmation samples at 10 percent of the locations will be collected for offsite laboratory analysis of site-specific COCs by EPA Method TO-15. Refer to **Worksheet #17**. An MLE analysis is planned that considers groundwater concentrations, soil gas concentrations (including cumulative risk considerations), stratigraphy, and characteristics of overlying buildings.	Refer to **Worksheets #24, #28**, and **#36** for acceptance and performance criteria. Laboratory data are considered usable if data validation criteria are met (refer to **Worksheet #37** for data usability criteria).	Refer to **Worksheet #17** for details on the sample collection design and rationale.
2	The potential for complete and significant VI pathways has not been investigated at all of the occupied buildings in the inclusion zone (defined based on a buffer around the groundwater VISL plume area) south and west of the Behr facility. A subset of buildings in this area has previously been investigated or is scheduled for investigation by others.	The goal is to assess the potential for complete and significant VI pathways in the groundwater VISL plume area south and west of the Behr facility at up to 15 occupied buildings selected by EPA that have not been previously sampled and where access is granted.	Building survey information (that is, building construction, use, and occupancy) pertinent to the VI pathway. Interior VI sampling results (indoor air, subslab soil vapor and/or crawlspace air as appropriate for each building) and site-wide outdoor air sampling results for site-specific COCs. Groundwater results and any available external soil gas results in the vicinity of the properties evaluated. EPA and Ohio EPA VISLs and EPA RMLs. Two rounds of interior VI sampling at buildings with indoor air concentrations below the RMLs, or indoor air concentrations are above the RMLs but not likely due to VI based on MLE.	Occupied buildings selected by EPA that have not previously been sampled and where access is granted expected to be in the groundwater VISL plume area south and west of the Behr facility.	The indoor air, subslab soil vapor, and/or crawlspace air samples will be collected for offsite laboratory analysis of site-specific COCs by EPA Method TO-15/TO-15 SIM. Refer to **Worksheet #17**.	Refer to **Worksheets #24, #28**, and **#36** for acceptance and performance criteria. Laboratory data are considered usable if data validation criteria are met (refer to **Worksheet #37** for data usability criteria).	Refer to **Worksheet #17** and Figure 2 for details on the sample collection design and rationale.

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Who will use the data?

The data will be used by CH2M, EPA, and Ohio EPA; and the property owners will be presented with the final validated analytical data.

What will the data be used for?

The data evaluations for the two separate investigations will be performed as follows:

- **Soil vapor plume delineation northeast and east of the Behr facility**
  - Exterior soil vapor sampling results will be used to delineate the deep (near source) soil vapor plume(s) (PCE, TCE, cis-1,2-DCE, 1,1,1-TCA, and/or VC).
  - The dual-depth exterior soil vapor sampling results will be used to assess the vertical profile of PCE, TCE, cis-1,2-DCE, 1,1,1-TCA, and VC in soil vapor. The dual-depth information will allow evaluation of whether the rate of diffusive transport is sufficient to sustain concentrations above screening levels at or below typical building foundation depths. The shallow soil vapor probes will additionally provide information about the potential for vadose zone VOC sources in their vicinity.
  - Exterior soil vapor sampling results may be compared to historical shallow groundwater and soil sampling VOC results to assess if VOCs measured in soil vapor are likely due to off-gassing from groundwater or if there is a potential for separate vadose zone VOC sources.
  - Results from the laboratory confirmation samples will be compared to their paired HAPSITE results to assess the accuracy of the HAPSITE results.
- **Interior VI sampling south and west of the Behr facility** - Building survey information, interior VI sampling results (indoor air, and subslab soil vapor and/or crawlspace air), and outdoor air sampling results will be used in a MLE evaluation to assess the potential complete and significant VI pathways at each building. The MLE evaluation will be used to determine if site-related VOCs detected in indoor air, crawlspace air, and subslab soil vapor are related to VI or potentially present as a result of background sources. The following lines of evidence will be considered:
  - Measured VOC concentrations in subslab soil vapor, crawlspace air, and/or indoor air compared to VISLs and RMLs.
  - Measured VOC concentrations in nearby exterior soil vapor and/or shallow groundwater.
  - The presence of potential preferential VI pathways that are intersecting areas of elevated soil vapor VOC concentrations, and then travel near buildings.
  - The presence of readily identifiable potential preferential VI pathways through the building envelope (poorly sealed utility conduits, abandoned drains, sumps, substantial cracks in the slab or basement walls, etc.).
  - Comparison of outdoor air (sitewide) to indoor air concentrations to evaluate potential background outdoor air VOC sources.
  - The presence of potential indoor VOC sources identified during the building survey.
  - Building construction features or conditions that could increase or decrease the likelihood of VI such as the interior volume, compartmentalization, outdoor air exchange, and air mixing in the building.
  - Comparison of measured VOCs in indoor air, subslab soil vapor, and/or crawlspace air.

- Comparison of VOC concentration ratios in indoor air, subslab soil vapor, and/or crawlspace air.
- Comparison of VOC concentrations between the two sampling rounds.

What types of data are needed?

- **Soil vapor plume delineation northeast and east of the Behr facility** – PCE, TCE, cis-1,2-DCE, 1,1,1-TCA, and VC results from up to 32 deep exterior soil vapor probes (Figure 2), four of which will be dual-depth probes (with an additional shallow screen), in the groundwater VISL plume area north and east of the Behr facility collected as described in **Worksheet #17**.
- **Interior VI sampling south and west of the Behr facility** - Building survey information, interior VI sampling results (indoor air, and subslab soil vapor and/or crawlspace air), and outdoor air sampling results for site-specific COCs, collected from occupied buildings selected by EPA that have not been previously sampled, in the groundwater VISL plume area, south and west of the Behr facility (Figure 2). Two rounds of sampling, approximately 6 months apart will be performed at buildings with indoor air concentrations below the RMLs, or indoor air concentrations above the RMLs but not due to VI based on MLE.

Task	Sampling Activity/Objective	Sampling Frequency/ Duration	Matrix	Parameters
Soil vapor	Soil vapor sampling (Refer to DQO #1)	One round	Soil vapor	PCE, TCE, cis-1,2-DCE, 1,1,1-TCA, and VC (HAPSITE) and site-specific COCs (analytical laboratory)
Subslab soil vapor	Subslab soil vapor sampling (Refer to DQO #2)	Up to two rounds	Soil vapor	Site-specific COCs (analytical laboratory)
Indoor air, crawl space air, and outdoor air	Indoor air, crawl space air, and outdoor air (Refer to DQO #2)	Up to two rounds	Indoor air, crawl space air, and outdoor air	Site-specific COCs (analytical laboratory)

How “good” do the data need to be in order to support the environmental decision?

The data should meet the project action levels as specified in QAPP **Worksheets #15-1** and **#15-2**, and the quality control (QC) requirements that are explained in QAPP **Worksheet #37**.

Worksheets #15 and #15-2 presents analytical methodology and limits. In addition to listing the particular analytes, project screening levels, and limits, the table identifies where analytical reporting limits (QLs) or method detection limits (MDLs) are greater than the project’s screening levels.

How many data are needed? (Number of samples for each analytical group, matrix, and concentration)

Worksheet #17 (Sampling Design and Rationale) describes the field investigation activities including the rational for the spacing of the external sample locations and number of indoor sampling locations per structure. **Worksheet #18** (Sampling Locations and Methods) summarizes the number of samples and the analytical parameters.

Where, when, and how should the data be collected/ generated?

Detailed information on where, when, and how the data will be collected is provided in **Worksheets #17 and #18**.

Who will collect and generate the data?

CH2M will collect environmental samples. The HAPSITE GC/MS will be used by CH2M to perform in-field analysis of the exterior soil vapor samples. The subcontracted analytical laboratory will generate the data results for the confirmation exterior soil vapor samples, interior VI samples (indoor air, subslab soil vapor, and/or crawlspace air), and outdoor air samples. The laboratory SOPs are provided as **Appendix B**.

How will the data be reported?

The data will be reported in accordance with procedures outlined in **Worksheet #36**. A report will be prepared including an MLE analysis documented in tabular form for each individual building sampled in depth and for appropriate portions of the northern and eastern areas where only external soil gas probes are being installed under this project. Electronic (such as database management system and GIS) data will be stored by CH2M for 10 years after project completion.

How will the data be archived?

The final evidence file will be the central repository for documents that constitute evidence relevant to sampling and analysis activities. CH2M will be the custodian of the evidence file and will maintain the contents of the evidence files for the project, including relevant records, reports, logs, field notebooks, sketches, pictures, contractor reports, and data reviews, in a secured area with limited access. CH2M will keep records for 10 years after contract completion. As necessary, records may be transferred to an offsite records storage facility. The records storage facility must provide secure, controlled access records storage.

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Worksheet #12—Measurement Performance Criteria

The measurement performance criteria (MPC) for chemical analyses being performed for each matrix and analytical parameter are summarized in Table 12-1 on the following page. The MPCs follow those defined in the referenced EPA method or laboratory SOPs. The quality of the data to be collected for this project will be verified through appropriate MPCs established for both sampling procedures and analytical methods. The criteria relate to data quality indicators (DQIs), consisting of precision, accuracy, representativeness, comparability, completeness, and sensitivity, commonly referred to as precision, accuracy, representativeness, comparability, completeness, and sensitivity (PARCCS) parameters. The DQIs are defined as follows:

- **Precision** refers to the reproducibility of measurements. Precision is usually expressed as standard deviation, variance, percent difference, or range, in either absolute or relative terms.
- **Accuracy** refers to the degree of agreement between an observed value (such as sample results) and an accepted reference value. A measurement is considered accurate when the reported value agrees with the true value or known concentration of the spike or standard within acceptable limits.
- **Representativeness** describes the extent to which a sampling design adequately reflects the environmental conditions of a site. Representativeness is determined by appropriate program design, with consideration of elements such as proper well locations, drilling and installation procedures, operations process locations, and sampling locations.
- **Comparability** addresses the degree to which different methods or data agree or can be represented as similar. Comparability is achieved by using standard methods for sampling and analysis where available, reporting data in standard units, normalizing results to standard conditions, and using standard and comprehensive reporting formats.
- **Completeness** is a measure of the amount of valid data collected using a measurement system. Completeness is expressed as a percentage of the number of measurements that are specified in this UFP QAPP.
- **Sensitivity** is the ability of a method or instrument to detect the target analytes at the level of interest. Sensitivity can be measured by calculating the percent recovery of the analytes at the detection limit, which is the minimum concentration of an analyte that can be routinely identified and quantified above the method detection limit by a laboratory.

The quality of the sampling procedures and laboratory results will be evaluated for compliance with project data quality objectives (DQOs) through a review of overall PARCCs (EPA, 2009), in accordance with procedures described in **Worksheet #37** (Data Usability Assessment). The results will be summarized in an overall data usability report.

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Worksheet #12-1—Measurement Performance Criteria Table

Matrix Indoor, Outdoor, and Crawlspace Air, and Exterior and Subslab Soil Vapor

Analytical Group VOCs

Concentration Level Low

Sampling Procedure[a]	Analytical Method/SOP[b]	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S & A)
FOP-04, FOP-09 and FOP-10	Lab SOP #1	Precision	RPD ± 25% if both samples are > 5xRL	FD	S & A
			RPD ± 25% if both samples are > 5xRL	LD	A
		Accuracy/bias	70-130 % Recovery	LCS, Surrogates	A
		Completeness[c]	> 90% Laboratory Analysis[c]	Percent Completeness	S & A
		Representativeness	Contamination of sample	MB	A
		Comparability	Qualitative measure for field sampling procedures	LCS	A

[a] Reference number from QAPP **Worksheet #21**
[b] Reference number from QAPP **Worksheet #23**

[c] While this goal for overall completeness is an appropriate way to assess overall project performance, given the individualized nature of VI decisions, the loss of a single data point may reduce the ability to reach a final decision about the path forward for a given building and necessitate resampling.

Notes:

FD = field duplicate, LD = laboratory duplicate, LCS = laboratory control sample, MB = method blank, RPD = relative percent difference

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Worksheet #12-2—Measurement Performance Criteria Table

Matrix	Exterior Soil Vapor (Primarily by HAPSITE with a Subset of Samples Confirmed with Laboratory Analysis)
Analytical Group	VOCs
Concentration Level	Low

Sampling Procedure[a]	Analytical Method/SOP[a]	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S & A)
FOP-04	FOP -05	Precision	RPD ± 25% if both samples are > 5xRL	FD	S & A
		Accuracy/bias	70-130 % Recovery	Calibration Verification	A
		Completeness[c]	> 90% Field Analysis[b]	Percent Completeness	S & A
		Representativeness	Contamination of sample	MB	A
		Comparability	Comparability to a subset of confirmation laboratory samples will be assessed as discussed in **Worksheet #37**.	Split samples	S&A

[a] Reference number from QAPP **Worksheet #21**

[b] While this goal for overall completeness is an appropriate way to assess overall project performance, given the individualized nature of VI decisions, the loss of a single data point may reduce the ability to reach a final decision about the path forward for a given building and necessitate resampling.

Notes:

FD = field duplicate, MB = method blank, RPD = relative percent difference

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Worksheet #13—Secondary Data Uses and Limitations

Secondary Data	Data Source	Data Generator(s)	How Data Will Be Used	Limitations on Data Use
Municipal GIS information	Montgomery County Assessor's Office	Montgomery County, Ohio	GIS information will identify current building location, size, and ownership.	None
Draft Remedial Investigation Report	Draft Remedial Investigation Report (CH2M, 2016)	CH2M	Static water levels will be used to assess use of multi-depth vapor probes; groundwater and soil concentrations will be used to select site specific COCs, and sampling locations.	None
Previous VI sample locations	Excel tables from AECOM (consultant to the Behr Facility)	AECOM	Previously sampled buildings will be removed from the data set.	None

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Worksheets #14 and #16—Project Tasks and Schedule

Fieldwork/Sampling Tasks

Applicable SOPs for the project tasks outlined in this worksheet are listed on **Worksheet #21** and in **Appendix A**.

Soil Vapor Plume Delineation Northeast and East of the Behr Facility

Listed below is a summary of the field and sampling tasks. See **Worksheet #17** for a detailed description of all procedures discussed below.

Access Agreements

Prior to mobilization, access agreements will be secured from the locations requiring drilling for the exterior soil vapor sampling (Figure 2). Drilling will primarily take place in City street right-of-way (ROWs); therefore, access will be requested from the City of Dayton engineering/street department. Access that may be required on private properties will be secured as well.

Reconnaissance/Utility Locating

The precise locations of proposed drilling locations will be identified during a driving reconnaissance of the area. Locations will be chosen that are representative of the modeled VISL groundwater plume, within properties where access was granted, away from overhead and subsurface utilities, and which can be drilled safely. Subsurface utility locating will be completed by both the federal 811 process and through the use of a private, third-party locating firm. The proximity both horizontally and vertically of soil gas points to utility corridors including sewers will be documented to assist in later data interpretation (migration of VOCs relevant to VI could have occurred either through groundwater advective flow or through preferential pathways involving utilities). If possible, information will be obtained to allow the relative vertical position of sewers to the static water table in this area to be assessed.

Drilling/Sampling

Soil vapor sampling will be completed using a direct-push technology (DPT) drill rig. Samples will be analyzed with a field portable gas chromatography–mass spectrometry (GC/MS) HAPSITE site and through confirmation samples collected in air canisters. Confirmation sample locations will be selected in the field to encompass a range of concentrations observed with the HAPSITE. Soil lithology and depth to groundwater information will also be collected from the DPT drilling effort.

IDW Management

Decontamination fluids, soils, personal protective equipment (PPE), and trash will be containerized and stored at a staging area. The waste will be characterized, transported, and disposed of at an approved facility within 90 days of generation.

Surveying

Actual locations drilled and sampled will be geolocated using a sub-meter accuracy, hand-held, global positioning system (GPS) unit. The coordinates will be uploaded to the project database.

Interior Vapor Intrusion Sampling South and West of the Behr Facility

Listed below is a summary of the field and sampling tasks. See **Worksheet #17** for a detailed description of all procedures discussed below.

Access Agreements

Using tax information obtained from the Montgomery County Assessors office, access agreements were mailed to the landowners of all buildings within the VISL area thought to be occupied and not having been sampled for VI previously in May 2017 (Figure 2). EPA will select the buildings for the interior VI sampling and will obtain signed access agreements from the property owners prior to sampling.

Building Survey/Utility Locating

CH2M will visit each location for which access is granted to conduct a building survey and choose locations for sampling. A private, third-party utility locator will scan proposed locations for subsurface utilities.

Drilling/Sampling

Subslab samples will be collected through the concrete slab using a vapor pin installed with a hand-held concrete drill. Indoor, crawspace, and outside air samples will be collected directly. See **Worksheet #17** for a detailed description of the field sampling activities.

IDW Management

Decontamination fluids, soils, PPE, and trash will be containerized and stored at a staging area. The waste will be characterized, transported, and disposed of at an approved facility within 90 days of generation

Surveying

The location of each building sampled will be entered into the project database. The location information will be taken from the existing Montgomery County GIS system, precluding the need for a third-party survey.

Analysis Tasks

CH2M's subcontracted laboratory will analyze confirmation soil vapor, subslab soil vapor, indoor air, outdoor air and crawlspace air samples for the site-specific COC list.

CH2M's subcontracted laboratory will also analyze solid and liquid investigation-derived waste (IDW) samples, though those results will not require validation. CH2M will operate a field portable HAPTSITE GC/MS for analysis of exterior soil vapor samples for PCE, TCE, and 1,1,1-TCA, which will also not require validation.

The specific methods for these analyses are found in **Worksheet #21**, for the field portable HAPSITE GC/MS, and **Worksheet #23**, for the subcontracted laboratory.

Quality Control Tasks

Implement SOPs. See **Worksheets #11, #12, #15, #22, #24, #25, #27,** and **#28** for items related to QC. QC samples are described in **Worksheet #28**.

Secondary Data

See QAPP **Worksheet #13**.

Data Management Tasks

The following are the team members and their responsibilities for the data management process:

- **Project Chemist—**Responsible for providing weekly the chain-of-custody forms and establishing the sample tracking system. Oversees proper use of EPA's sample management system (Scribe) and accuracy of the information entered. Reviews laboratory data for accuracy and quality and compares electronic outputs for accuracy to laboratory electronic copies. Conducts tracking of samples, forwards tracking information and received data to the database manager, and identifies the data inputs (for example, sample numbers) to use in generating tables and plots.
- **Database Manager—**Responsible for setting up the data management system in consultation with the project chemist at the beginning of the data evaluation task. Also oversees the data management process, including data conversion/manual entry into the data management system, QC of the entered data, and preparation of the required tables and plots of the data. Coordinates with the person responsible for reviewing the entered data for QC purposes. Forwards deliverables to the site manager.

  Management of data outside of analytical results, such as building survey forms, HAPSITE sample forms, and boring logs, will be administered per the data management plan (DMP) submitted separately from this QAPP.
- **GIS Manager—**Responsible for coordinating with the site manager to set up the geodatabase prior to sampling. Maintains spatial layers and overall geodatabase integrity and accuracy. Provides GIS-related outputs for reports.

Sample Tracking

The project chemist is responsible for tracking samples in the sample tracking database to ensure that the analytical results for samples sent for analysis are received. Copies of chains of custody from the field team are used to enter in sample identifications (IDs), collect date, and analyses. Upon receipt of a sample receipt notice from the laboratory, the date received by the laboratory, and a date the electronic copy is due will be entered. Likewise, upon receipt of the electronic copy and EDD, the date they were received will also be entered. The EDDs will be uploaded when received from the laboratory and will be tracked in the sample tracking table. Validation qualifiers will be added to the database and the results will be qualified accordingly.

Data Types

The data will be added to the project database as they become available. The data will include new data collected in the laboratory and validated by CH2M. These laboratory data include analytical results, relevant field data, and sample location coordinates will be included. Data sources will be noted in the database.

Survey data, collected by a sub-meter hand-held GPS unit, will be incorporated into the GIS database and maintained by the GIS Manager.

Other non-analytical, project data such as sampling forms, boring logs, building survey forms, and HAPSITE analysis information will be included in the DMP to be submitted separately from this QAPP.

Data Tracking and Management

Every data set received from analytical laboratories will be tracked individually. Analytical laboratory reports of chemical analysis results will be tracked in a consistent fashion. Every data set will be assigned a unique identifier. The date of receipt, status of data validation, and status of database entry for each data set will be tracked and recorded in the project database.

Hard/Electronic Copy

Measurements made during field data collection activities will be recorded in field logbooks and sample processing logs. Field data will be reduced and summarized, tabulated, and stored along with the field logbooks and sample processing logs.

The raw analytical laboratory data are stored electronically.

Data Input Procedures

Sampling information, analytical results, applicable QA/QC data, data validation qualifiers, and other field-related information will be entered into the project database for storage and retrieval during data evaluation and report development. The analytical data will be loaded into the database using EDD files received from the analytical laboratory. Validation qualifiers will be applied to the dataset either electronically or manually. Other available field-related data collected will be manually entered onto standard EDD templates for loading into the database. Historical data, either in hard copy or electronic form, will be manually entered on or formatted to standard EDD templates for database loading.

Computer Database

The technical data including sample location information, laboratory analytical results, and analytical data validation will be managed using EQuIS 6.6, a third-party database system by EarthSoft, Inc., that is used in EPA Region 5 to store and analyze project data submissions. The core EQuIS applications are its chemistry and geology modules, each of which is associated with its own underlying Microsoft SQL Server database. CH2M owns licenses for the geology and chemistry modules. The EQuIS database system is based on a relational model in which independent tables, each containing a certain type or entity of data, can be linked through selected fields that are common to two or more tables. The database design allows for the inclusion of historical data, and allows users to effectively conduct trend analysis and generate a variety of data reports to aid in data interpretation.

The database will be protected from unauthorized access, tampering, accidental deletions or additions, and data or program loss that can result from power outages or hardware failure. The following procedures will be adopted to ensure protection:

- The master database will be stored hosted by EarthSoft, Inc. on a network file server with web access from a local to the installation of the EQuIS data management system and access via EQuIS Enterprise web interface. Members of the data management team involved in loading, modifying, or querying the database will be given access through EQuIS user accounts and passwords, as well as the appropriate network server permissions.

- EQuIS Enterprise provides users with a Web-based interface that allows for data reporting in standard formats. Where required, data exports from copies of the master database will be stored on the local area network for access by project staff through custom reporting tools developed to minimize possible database corruption by users. Whenever the master database is updated or modified, the data will be recopied exported to the local area network to ensure that the current copy data set is available to users.
- Daily backups of the master database and its copies will be made to ensure that the data will not be lost due to problems with the network. Each night, a daily differential backup will be performed by EarthSoft, Inc. Then, each week a full backup will be completed by EarthSoft, Inc. The backups are stored on a SAN device located in Utah, and are then transferred to an offsite data center.

GIS Description

A project geodatabase will be set up prior to sampling by the GIS manager. Workflow for creating, maintaining, and organizing geospatial data will follow the Spatial Data Standard format for projects whenever possible.

An ArcView project or extension will be used providing the following functionality: load and display project site base maps; display sampling station locations and associated sampling data (date, media, and results); and perform ad hoc queries to highlight sampling locations meeting user-entered criteria for sampling (for example, data by date, sample type, analyte, depth/elevation, result value, or any combination thereof). Results will be shown as stations highlighted on the map.

Documentation

Documentation of data management activities is critical because it provides the following:

- An electronic copy record of project data management activities
- Reference information critical for database users
- Evidence that the activities have been properly planned, executed, and verified
- Continuity of data management operations when personnel changes occur

The data management plan will serve as the initial general documentation of the project data management efforts. Additional documentation will be maintained to document specific issues such as database structure definitions, database inventories, database maintenance, user requests, database issues and problems, and client contact.

Evidence File

The final evidence file will be the central repository for documents that constitute evidence relevant to sampling and analysis activities. CH2M is the custodian of the evidence file and maintains the contents of the evidence files for the project, including relevant records, reports, logs, field notebooks, sketches, pictures, contractor reports, and data reviews in a secured area with limited access.

CH2M will keep records until project completion and closeout. As necessary, records may be transferred to an offsite records storage facility. The records storage facility must provide secure, controlled-access records storage. Records of raw analytical laboratory data, QA data, and reports will be kept by the laboratory for at least 5 years.

Presentation of Study Data

Depending on data user needs, data presentation may consist of the following formats:

- Tabulated results of data summaries or raw data.

- Figures showing soil gas concentration isopleths or location-specific concentrations at two depths.
- Figures showing results of subslab or indoor air samples superimposed on basic building outlines/ floor plans.
- Tabular presentation of multiple lines of evidence analyses.
- Tables providing statistical evaluation or calculation results.
- Presentation tools, such as ARCINFO or similar analysis/ presentation aids.

In addition to laboratory data, other physical data will be collected during field efforts. The information will be stored in the project database. Other types of data elements may be added as the field investigation needs and activities evolve.

Assessment and Audit Tasks

See **Worksheets #31, #32**, and **#33**.

Data Review Tasks

The laboratory will make sure the data are complete for all samples received. The data will be validated by CH2M using the National Functional Guidelines, laboratory SOPs, and the QAPP.

Validated data and field logs will be reviewed to assess total measurement error and determine overall usability of the data for project purposes. Final data are placed in the database with qualifiers.

As discussed in **Worksheet #12**, the CH2M lead for the HAPSITE work will similarly evaluate the completeness of the external soil gas analyses and conduct a data verification.

See **Worksheets #34** though **#37** for the tasks.

Documentation and Records

Records and field measurements of all samples will be collected in field books and scanned electronically. Data collected in the field with the HAPSITE produces electronic raw data files, which are processed to produce xls/csv files, which are then stored on a sharepoint directory. Those files can then be backed up/archived with the project files. Chains of custody, air bills, and sample logs will be prepared and retained for each sample. Soil boring, soil vapor probe, and other field data (e.g., field sampling forms) will be obtained from the subcontractor and retained electronically. A copy of the final QAPP will be kept at the CH2M Cincinnati, Ohio, office.

Project Schedule

		Dates			
Activities	**Organization**	**Anticipated Date(s) of Initiation**	**Anticipated Date of Completion**	**Deliverable**	**Deliverable Due Date**
Site-specific Plans	CH2M	May 9, 2017	September 22, 2017	Site-specific plans	September 22, 2017
EPA Review of QAPP	CH2M	September 22, 2017	October 20, 2017	QAPP	NA
Access Agreements	CH2M	May 15, 2017	July 11, 2017	NA	NA
Site Reconnaissance	CH2M	September 27, 2017	September 27, 2017	NA	NA
Exterior Soil Vapor Sampling	CH2M	October 23, 2017	October 29, 2017	NA	NA
Laboratory Analysis	ALS Global	Within required analytical holding times	21 business days	Data package	21 business days
Building Surveys, Utility Locates, and Subslab Soil Vapor Probe Installs and Sampling	CH2M	November 6, 2017	December 6, 2017	NA	NA
Laboratory Analysis	ALS Global	Within required analytical holding times	21 business days	Data package	21 business days
Data Validation (both Ext. Soil Vapor and Round 1)	CH2M	After receipt of analytical data reports	21 business days after receipt of final data	Data validation report	21 days after receipt of final data
Data Evaluation (both Ext. Soil Vapor and Round 1)	CH2M	After receipt of final data	45 business days after receipt of validated data	Data evaluation tech memo	45 days after receipt of validated data
Database Management	CH2M	October 23, 2017	July 6, 2018	Database	NA
Round 2 VI Sampling	CH2M	May 7, 2017	June 1, 2018	NA	NA
Laboratory Analysis	ALS Global	Within required analytical holding times	21 business days	Data package	21 business days
Data Validation	CH2M	After receipt of analytical data reports	21 business days after receipt of final data	Data validation report	21 days after receipt of final data
Data Evaluation	CH2M	After receipt of final data	45 business days after receipt of validated data	Data evaluation tech memo	45 days after receipt of validated data

Dates

Activities	Organization	Anticipated Date(s) of Initiation	Anticipated Date of Completion	Deliverable	Deliverable Due Date
Work Assignment Closeout	CH2M	August 24, 2018	August 31, 2018	NA	NA

Note:

NA = not applicable

Worksheet #15-1—Project Action Limits and Laboratory-Specific Detection/Quantitation

A site-specific VI COC list was developed for both investigations detailed in this QAPP (the soil vapor plume delineation northeast and east of the Behr facility and the interior VI sampling southwest of the Behr facility). The site-specific VI COC list was developed by identifying each of the VOCs that have been historically measured in groundwater samples at concentrations exceeding the VISLs. VOCs that were not included in the analytical laboratory's standard EPA Method TO-15 and TO-15 SIM lists were removed. The 16 VOCs identified in the table below were identified as the site-specific VI COCs.

For real time field decision making, the HAPSITE is best utilized by analyzing up to five VOCs. Therefore, the exterior soil vapor samples will be analyzed with the HAPSITE for PCE, TCE, cis-1,2-DCE, 1,1,1-TCA, and VC because they are the primary site-related VOCs as discussed in **Worksheet #10**. The confirmation soil vapor samples will be analyzed for the site-specific VI COC list.

The ability of the subcontracted laboratory to meet the project action limits is critical to the successful outcome of the project. The laboratory will report results from all valid analyses including multiple dilutions, if needed, to provide the results with the lowest possible dilution factor. If the presence of a single compound or sample matrix would risk serious instrument contamination the lowest possible dilution to prevent this contamination should be used.

Matrix: Exterior and Subslab Soil Vapor
Analytical Group: VOCs (TO-15)
Concentration Level: Low

		Residential Properties			Commercial Properties			Achievable Laboratory Limits[d]	
Analyte	**CAS Number**	**EPA Residential Soil Vapor VISL[a] (µg/m³)**	**Ohio EPA Residential Soil Vapor CRAL[b] (µg/m³)**	**EPA Residential Soil Vapor RML[c] (µg/m³)**	**EPA Commercial Soil Vapor VISL[a] (µg/m³)**	**Ohio EPA Commercial Soil Vapor CRAL[b] (µg/m³)**	**EPA Commercial Soil Vapor RML[c] (µg/m³)**	**QLs (µg/m³)**	**MDLs (µg/m³)**
Benzene	71-43-2	12	120	1,200	52	520	5,200	1.30	0.40
Bromomethane (Methyl bromide)	74-83-9	17	170	520	73	730	2,200	1.30	0.48
Carbon tetrachloride	56-23-5	16	160	1,600	68	680	6,800	1.30	0.38
Chloroform (Trichloromethane)	67-66-3	4.1	41	410	18	180	1,800	1.30	0.43
Chloromethane (Methyl chloride)	74-87-3	310	3,100	9,400	1,300	13,000	39,000	1.30	0.38
cis-1,2-Dichloroethene	156-59-2	--	--	--	--	--	--	1.30	0.40
1,3-Dichlorobenzene[e]	541-73-1	8.5	85	580	37	370	3,800	1.30	0.38
Dichlorodifluoromethane (CFC-12)	75-71-8	350	3,500	10,000	1,500	15,000	44,000	1.30	0.43
1,1-Dichloroethane	75-34-3	58	580	5,800	260	2,600	26,000	1.30	0.40
1,2-Dichloroethane	107-06-2	3.6	36	360	16	160	1,600	1.30	0.40
1,1-Dichloroethene	75-35-4	700	7,000	21,000	2,900	29,000	88,000	1.30	0.43
Ethylbenzene	100-41-4	37	370	3,800	160	1,600	16,000	1.30	0.40
Tetrachloroethene	127-18-4	140	1,400	4,200	580	5,800	18,000	1.30	0.35
1,1,1-Trichloroethane	71-55-6	17,000	170,000	520,000	73,000	730,000	2,200,000	1.30	0.43
Trichloroethene	79-01-6	7.0	70	70	29	290	290	1.30	0.35
Vinyl chloride	75-01-4	5.6	56	560	93	930	9,300	1.30	0.43

Matrix: Exterior and Subslab Soil Vapor

Analytical Group: VOCs (TO-15)

Concentration Level: Low

		Residential Properties			Commercial Properties			Achievable Laboratory Limits[d]	
Analyte	CAS Number	EPA Residential Soil Vapor VISL[a] (µg/m³)	Ohio EPA Residential Soil Vapor CRAL[b] (µg/m³)	EPA Residential Soil Vapor RML[c] (µg/m³)	EPA Commercial Soil Vapor VISL[a] (µg/m³)	Ohio EPA Commercial Soil Vapor CRAL[b] (µg/m³)	EPA Commercial Soil Vapor RML[c] (µg/m³)	QLs (µg/m³)	MDLs (µg/m³)

[a] The EPA soil vapor VISLs were developed from the EPA VI Calculator Version 3.5.1 using the June 2017 EPA Regional Screening Levels. The EPA soil vapor VISLs were developed for both residential and commercial/industrial exposure scenarios based on a TCR = 1 x 10^{-6} and a THQ = 1.

[b] The Ohio EPA soil vapor CRALs were developed from the EPA VI Calculator Version 3.5.1 using the June 2017 EPA Regional Screening Levels. The Ohio EPA soil vapor CRALs were developed for both residential and commercial/industrial exposure scenarios based on a TCR = 1 x 10^{-5} and a THQ = 1.

[c] The EPA soil vapor RMLs were developed from the EPA VI Calculator Version 3.5.1 using the June 2017 EPA Regional Screening Levels. The EPA soil vapor RMLs were developed for both residential and commercial/industrial exposure scenarios based on a TCR = 1 x 10^{-4} and a THQ = 3, except for TCE where a THQ =1 was used.

[d] Achievable laboratory limits applicable to 1 liter canister. These limits can also be met with the HAPSITE and Tedlar bag samples analyzed in the field.

[e] There is no RSL for 1,3-dichlorobenzene. The VISL for 1,4-dichlorobenzene is being used as a surrogate.

Notes:

VISL = vapor intrusion screening level; CRAL = chronic response action level; RML = removal management level; µg/m³ = microgram per cubic meter; QL = quantitation limit; MDL = method detection limit; TCR = target cancer risk; THQ = target hazard quotient

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Worksheet #15-2—Project Action Limits and Laboratory-Specific Detection/Quantitation

A site-specific VI COC list was developed as discussed in **Worksheet #15-1**.

Matrix:	Indoor, Outdoor, Crawlspace Air
Analytical Group:	VOCs (TO-15 SIM)
Concentration Level:	Low

		Residential Properties			Commercial Properties			Achievable Laboratory Limits[d]	
Analyte	**CAS Number**	**EPA Residential Indoor Air VISL[a] (µg/m³)**	**Ohio EPA Residential Indoor Air CRALs[b] (µg/m³)**	**EPA Residential Indoor Air RML[c] (µg/m³)**	**EPA Commercial Indoor Air VISL[a] (µg/m³)**	**Ohio EPA Commercial Indoor Air CRAL[b] (µg/m³)**	**EPA Commercial Indoor Air RML[c] (µg/m³)**	**RLs (µg/m³)**	**MDLs (µg/m³)**
Benzene	71-43-2	0.36	3.6	36	1.6	16	160	1.30	0.40
Bromomethane (Methyl bromide)	74-83-9	0.52	5.2	16	2.2	22	66	1.30	0.48
Carbon tetrachloride	56-23-5	0.47	4.7	47	2.0	20	200	1.30	0.38
Chloroform (Trichloromethane)*	67-66-3	0.12	1.2	12	0.53	5.3	53	1.30	0.43
Chloromethane (Methyl chloride)	74-87-3	9.4	94	280	39	390	1,200	1.30	0.38
cis-1,2-Dichloroethene	156-59-2	--	--	--	--	--	--	1.30	0.40
1,1-Dichloroethane	75-34-3	1.8	18	180	7.7	77	770	1.30	0.40
1,1-Dichloroethene	75-35-4	21	210	630	88	880	2,600	0.025	0.0086
1,2-Dichloroethane*	107-06-2	0.11	1.1	11	0.47	4.7	47	1.30	0.40
1,3-Dichlorobenzene[e]	541-73-1	0.26	2.6	26	1.1	11	110	1.30	0.38
Dichlorodifluoromethane (CFC-12)	75-71-8	10	100	310	44	440	1,300	1.30	0.43
Ethylbenzene	100-41-4	1.1	11	110	4.9	49	490	1.30	0.40
Tetrachloroethene	127-18-4	4.2	42	130	18	180	520	1.30	0.35

Matrix: Indoor, Outdoor, Crawlspace Air

Analytical Group: VOCs (TO-15 SIM)

Concentration Level: Low

		Residential Properties			Commercial Properties			Achievable Laboratory Limits[d]	
Analyte	CAS Number	EPA Residential Indoor Air VISL[a] (µg/m³)	Ohio EPA Residential Indoor Air CRALs[b] (µg/m³)	EPA Residential Indoor Air RML[c] (µg/m³)	EPA Commercial Indoor Air VISL[a] (µg/m³)	Ohio EPA Commercial Indoor Air CRAL[b] (µg/m³)	EPA Commercial Indoor Air RML[c] (µg/m³)	RLs (µg/m³)	MDLs (µg/m³)
Trichloroethene	79-01-6	0.21	2.1	2.1	0.88	8.8	8.8	1.30	0.35
1,1,1-Trichloroethane	71-55-6	520	5,200	16,000	2,200	22,000	66,000	1.30	0.43
Vinyl chloride	75-01-4	0.17	1.7	17	2.8	28	280	1.30	0.43

[a] The EPA indoor air VISLs were developed from the EPA VI Calculator Version 3.5.1 using the June 2017 EPA Regional Screening Levels. The EPA indoor air VISLs were developed for both residential and commercial/industrial exposure scenarios based on a TCR = 1 x 10^{-6} and a THQ = 0.1. A THQ was used for the EPA indoor air VISLs because several of the site-specific COCs have non-cancer risks for the same target organs.

[b] The Ohio EPA indoor air CRALs were developed in accordance with the Ohio EPA (2016) *Guidance Document: Recommendations Regarding Response Action Levels and Timeframes for Common Contaminants of Concern at Vapor Intrusion Sites in Ohio*. The Ohio EPA indoor air CRALs were developed from the EPA VI Calculator Version 3.5.1 using the June 2017 EPA Regional Screening Levels. The Ohio EPA indoor air CRALs were developed for both residential and commercial/industrial exposure scenarios based on a TCR = 1 x 10^{-5} and a THQ = 1.

[c] The EPA indoor air RMLs were developed from the EPA VI Calculator Version 3.5.1 using the June 2017 EPA Regional Screening Levels. The EPA indoor air RMLs were developed for both residential and commercial/industrial exposure scenarios based on a TCR = 1 x 10^{-4} and a THQ = 3, except for TCE where a THQ =1 was used.

[d] Achievable laboratory limits applicable to 6-liter canister

[e] There is no RSL for 1,3-dichlorobenzene. The VISL for 1,4-dichlorobenzene is being used as a surrogate.

Notes:

VISL = vapor intrusion screening level; CRAL = chronic response action level; RML = removal management level; µg/m³ = microgram per cubic meter; QL = quantitation limit; MDL = method detection limit; TCR = target cancer risk; THQ = target hazard quotient.

* Compounds whose reporting limits exceed their respective VISL will be evaluated in the Data Quality Evaluation (DQE) report. These chemicals are not risk drivers for this site.

Worksheet #17—Sampling Design and Rationale

Two separate investigations will be performed at the site for this project as follows:

- **Soil vapor plume delineation northeast and east of the Behr facility** - Exterior soil vapor sampling will be performed in the groundwater VISL plume area north and east of the Behr facility where groundwater concentrations are relatively lower to delineate the soil vapor plume (PCE, TCE, cis-1,2-DCE, 1,1,1-TCA, and VC). Temporary exterior soil vapor probes will be installed and sampled at up to 32 locations (Figure 2). The soil vapor probe screens will be placed approximately 3 to 5 feet above the groundwater table which will be determined from historical groundwater elevation information and up to 10 soil borings. Additionally, dual-depth probes, with the shallow screen approximately 5 to 6 feet bgs, will be installed at four of the up to 32 locations.
- **Interior VI sampling southwest of the Behr facility** - Interior VI sampling will be performed at occupied buildings selected by EPA located within the Behr Dayton Thermal VOC groundwater VISL plume that have not yet been sampled. The interior VI sampling will include performing building surveys and collecting interior VI samples (indoor air, and subslab soil vapor and/or crawlspace air) and outdoor air samples as discussed below. It is assumed that interior VI sampling will be performed at up to 15 buildings for planning purposes. A second round of interior VI sampling will be performed approximately 6 months after Round 1 at buildings where the first round of samples had measured concentrations below the EPA RMLs. It is assumed that a second round of interior VI sampling will be performed at eight of the 15 buildings for planning purposes.

The field activities will be conducted according to the FOPs provided in **Appendix A**. The proposed number of samples and the analytical parameters are summarized in **Worksheet #18** (Sampling Locations and Methods). A summary of historical site data used to select sampling points is presented in **Worksheet #13**.

Soil Vapor Plume Delineation Northeast and East of the Behr Facility

Temporary exterior soil vapor probes will be installed and sampled at up to 32 locations (Figure 2) in the groundwater VISL plume area northeast and east of the Behr facility. Proposed sampling locations are shown on Figure 2; however, the exact sampling locations will be selected during a site reconnaissance visit based on site conditions and will be based on the HAPSITE soil vapor results as they are obtained. Sampling will start at the Behr and Gem City facilities and move northeast and east within the groundwater plume boundary. The sampling locations will be placed in the City ROW as much a possible while avoiding underground utilities. The sample locations are spaced at approximate 200-foot intervals in the area to the east with relatively dense residential development, and at approximately 400 to 800 feet in the area to the north with commercial development on larger lots.

The soil vapor probe screens will be placed approximately 3 to 5 feet above the groundwater table, which will be determined from historical groundwater elevation information and up to 10 soil borings. Additionally, dual-depth probes, with the shallow screen approximately 5 to 6 feet bgs, will be installed and sampled at four of the up to 32 locations to assess the vertical profile of PCE, TCE, cis-1,2-DCE, 1,1,1-TCA, and VC in soil vapor. Installation of two of the dual-depth probes in areas close to the presumed Gem City and Behr source facilities will provide additional information to evaluate whether the targeted parcels might be impacted by transport through the vadose zone or shallow utilities.

Soil borings will be advanced at up to 10 locations to assess the soil types and depth to groundwater, which will support screen depth selection for the soil vapor probes.

Access Agreements

The majority of the soil vapor probes will be located within the City of Dayton ROW; however, some may be located on private property if access is granted. The City of Dayton will be notified of the planned sampling locations during field planning activities and its concurrence for the locations will be obtained. Access agreements will be mailed to up to four private property owners where seven of the proposed soil vapor probes are located.

Utility Clearance

Utility clearance of the 42 proposed drilling locations (up to 32 proposed soil vapor probe and up to 10 proposed soil boring) will be performed in accordance with Field Operating Procedure (FOP)-01 - *Utility Clearance for Intrusive Operations*. Utility drawings from the City of Dayton will be reviewed for the 42 proposed drilling locations prior to marking locations for clearance. The proposed drilling locations will be selected using Google Earth and then field-surveyed to look for utility, traffic, and other obstacles. The 42 proposed drilling locations will be marked with white paint and/or flags so that they can be cleared by both public (the 811 One-Call service) and private utility locators.

After completion of the public clearance process, a private utility-locating subcontractor will clear a 10-foot radius around each proposed drilling location as described in FOP-01 - *Utility Clearance for Intrusive Operations*.

Soil Borings

Soil borings will be advanced at up to 10 locations in the area where exterior soil vapor probes will be installed to assess the soil types and depth to groundwater which will support screen depth selection for the soil vapor probes. Existing site data from soil boring and groundwater sampling will be reviewed to assess soil types and depth to groundwater in the area where exterior soil vapor sampling will be performed. Up to 10 soil boring locations will be selected where there is insufficient existing information available.

Soil macrocores will be collected with a direct-push technology DPT rig. The soil cores will be characterized using the Unified Soil Classification System (USCS) in accordance with the *ASTM International Standard Practice for Description and Identification of Soil*s *(ASTM International D 2488)* as described in FOP-02 Soil Boring Logging.

Installation of Temporary Exterior Soil Vapor Probes

Temporary exterior soil vapor sample probes will be installed in accordance with the attached FOP-03 *Installation and Abandonment of Temporary Exterior Soil Vapor Probes*. The temporary soil vapor probes will be installed by DPT rig using the Geoprobe post-run tubing (PRT) system at a depth above the capillary fringe (approximately 3 to 5 feet above the water table), but no shallower than 5 feet bgs. The actual depth of each probe will be approximately predetermined based on the historical groundwater levels and nearby soil boring information in the vicinity of the location.

The DPT rod with an expendable point will be pushed to the target bottom screen depth and then retracted 6 inches to create an annular space at each soil vapor probe. A point popper will be run down the rods to confirm drop of the expendable point, and then the PRT adaptor and tubing will be post-run down the rods and screwed into the bottom of the rod.

Dual-depth soil vapor probes will be installed at four of the up to 32 locations. Separate probes will be installed for both depths at least 5 feet apart at these locations. Installation procedures will be the same as described above.

Collection of Soil Vapor Samples

The temporary exterior soil vapor sample probes will be sampled in accordance with the attached FOP-04 *Soil Vapor Sampling from Exterior Soil Vapor Probes*. Each soil vapor probe will be allowed to sit for 30 minutes after installation so that the subsurface has time to equilibrate. Collection of soil vapor samples may not be feasible at each of the proposed sample locations due to either a shallow water table or the presence of clay in the sample interval. Exterior soil vapor sampling will not be performed within 48 hours of a significant rain event (that is, 1 inch of rain in a 24-hour period).

After equilibrating, each soil vapor probe will be helium leak checked, and three dead volumes of soil vapor will be purged prior to sampling. The dead volume will include the probe and tubing. Leak checking is performed to confirm that the soil vapor probes were installed correctly so that ambient air will not be drawn into the sample, which would potentially dilute VOC concentrations. The leak-check procedure consists of placing a shroud around the soil vapor probe, flooding the shroud with helium gas, and measuring the helium concentration in the purged soil gas.

The soil vapor probes will be purged with a sampling manifold (consisting of stainless-steel Swagelok gas-tight valves and fittings) and a vacuum air pump. Soil vapor will be purged at 200 milliliters per minute (mL/min) into a Tedlar bag. The Tedlar bags will screened using a MiniRAE PID for total VOCs, a LandTec GEM Landfill Gas Meter for oxygen, carbon dioxide, and methane concentrations, and a MGD-2002 helium detector for helium concentrations.

The helium-leak check results are interpreted by comparing the helium concentration present in the purged soil vapor to those present in the shroud during purging. If the purged soil vapor contains helium at a concentration greater than 5 percent of the concentration present in the shroud, then the helium-leak check indicates that a leak exists, either in the sampling train or within the soil vapor probe, allowing helium (and ambient air) to be drawn into the probe screen. Attempts will be made to repair leaking probes, and if they are not successful then the probe will be reinstalled.

Exterior soil vapor samples will be collected in new 1 liter Tedlar bags and analyzed in the field with a HAPSITE field gas chromatogram in accordance with the attached FOP-05 *Analytical Method for the Determination of Volatile Organics in Soil Vapor or Air Using the HAPSITE Field GC/MS*. Confirmatory canister samples for laboratory analysis will be collected at 10 percent of the soil vapor probe locations. The confirmatory samples will be collected over a period of approximately 5 minutes in 1-liter canisters that are batch certified clean. Samples will be submitted to the subcontracted laboratory, ALS Global, for analysis of site specific VOCs by EPA Method TO-15 following the analytical SOP (Appendix B). Samples will be shipped to the following ALS Global location:

ALS Global
Kate Kaneko
2655 Park Center Drive, Suite A
Simi Valley, CA 93065

Soil vapor sampling activities will be documented in the field book and on the field data sheet included in FOP-04 *Soil Vapor Sampling from Exterior Soil Vapor Probes*. The coordinates of each probe location will be documented using a sub-meter hand-held GPS device.

Temporary Soil Vapor Probe Abandonment

Each of the soil vapor probes will be abandoned by removing the DPT rods and filling the borehole with a hydrated granular bentonite, and then the ground surface cover will be repaired as necessary (e.g., asphalt patch) to match the surrounding cover.

Equipment Decontamination

Equipment decontamination procedures are detailed in FOP-06 *Equipment Decontamination*. Non-disposable exterior soil vapor probe installation equipment will be decontaminated after each use. A three-stage decontamination process consisting of a wash with a non-phosphate detergent, a rinse with tap water and a final rinse with distilled water will be used. The onsite CH2M representative will use a PID to screen the equipment after decontamination to confirm that it is free of contaminants.

Investigation Derived Waste Characterization and Disposal

IDW generated during the exterior soil vapor sampling will include soil, decontamination water, and other miscellaneous contaminated debris (for example, PPE, acetate liners, plastic sheeting, etc.). Three waste streams, soil cuttings, liquids, and solids, are anticipated, and each waste stream will be separately containerized in 55-gallon drums.

IDW will be characterized and disposed of in accordance with local, state, and federal regulations as specified in the *Site Management Plan* (to be created after this QAPP submittal). Until disposal, the IDW will be held at a secure staging area. Soil samples will be collected and analyzed for the following: TCLP VOCs, TCLP SVOCs, TCLP Resource Conservation and Recovery Act (RCRA) metals, pH/corrosivity, and ignitability. Aqueous samples will be collected and analyzed for the following: VOCs, SVOCs, RCRA metals, pH/corrosivity, and flashpoint.

Miscellaneous wastes (soil vapor tubing, Tedlar bags, etc.) that did not come in contact with potentially contaminated soils or liquids will be disposed of as general solid waste in municipal trash receptacles.

Interior Vapor Intrusion Sampling South and West of the Behr Facility

Building surveys, interior VI sampling (indoor air, and subslab soil vapor and/or crawlspace air), and outdoor air sampling will be performed at the occupied buildings selected by EPA that have not been previously sampled expected to be in the groundwater VISL plume area south and west of the Behr facility (Figure 2).

One round of sampling will be performed at each building selected by EPA. A second round of sampling will be performed in buildings where the first round of indoor air concentrations of site-specific COCs do not exceed EPA RMLs or at locations where site-specific air COC concentrations exceed EPA RMLs but are not a result of subsurface issues.

The building survey, utility clearance, and subslab soil vapor probe installation will be completed during one visit to each building. Sampling at each property will then be performed requiring two or three visits to each building. Visit 1 will include deploying the indoor, outdoor, and/or crawl space air samples. Visit 2 will include collecting those samples. Visit 3 will include collecting the subslab soil vapor samples. Visits 2 and 3 may be combined if feasible at smaller buildings.

Access Agreements and Scheduling Sampling

A windshield site reconnaissance will be performed to confirm which buildings are vacant, occupied, or serviceable. Buildings that are obviously not in serviceable condition (such as boarded-up windows, missing walls or roof, etc.) will be photographed, will not be mailed access agreements, and will not be sampled.

One blank access agreement and cover letter will be mailed to each of the building owners with a self-addressed, stamped envelope (addressed to EPA). After an appropriate time, EPA will then send postcards to property owners who do not reply to the initial mailing. One attempt at an in-person visit will be made to each residential property owner who does not reply to the two mailing attempts (in-person visits will not be completed for commercial properties). Scheduling appointments with the property owners and/or tenants will be conducted by telephone for the VI sampling. A tracking table for property information, access agreements (mailings and responses), and VI sample scheduling will be generated and maintained throughout the VI field investigation.

Building Surveys

A building survey will be performed in accordance with FOP-07 *Conducting Building Surveys for Vapor Intrusion Investigations* at each of the selected buildings (where access was granted) prior to interior VI sampling. The building survey will include documenting building characteristics and conditions pertinent to VI. Such items include building use, building history and occupancy, approximate building dimensions, concrete floor slab condition and type, general operation of the HVAC systems, atypical preferential pathways, and the presence of chemical products that may be indoor sources of VOCs (that is, paint, gasoline cans, solvents, etc.). The exact subslab soil vapor and indoor air sampling locations will be selected with the property owners during the building survey.

For buildings that are not documented high-volume users of PCE or TCE (e.g., a home that may contain common household products that happen to contain PCE/TCE), a PID, such as the ppb-RAE with the capability of reading in units of ppb, will be used to screen the building to identify potential indoor VOC sources. The screening will focus on areas where chemical products that may contain VOCs are stored to identify if those products are confounding indoor VOC sources. Such products may be temporarily removed, if feasible, and the occupants will be instructed to refrain from such product use and activities for at least 24 hours prior to indoor air sampling, and during the sampling duration. Products identified as indoor VOC sources will be photographed and listed on the Building Survey Form included in FOP-07 *Conducting Building Surveys for Vapor Intrusion Investigations*.

Utility Clearance

Though the public 811 One Call system will be notified of the indoor utility locate, subsurface utility locating will be primarily completed through the third-party subcontractor. Utility clearance of the proposed subslab soil vapor probe locations will be performed in accordance with FOP-01 Utility Clearance for Intrusive Operations. A private utility locating subcontractor will then clear a 10-foot radius around each proposed location. The subcontractor will identify, mark out and differentiate between any underground utilities, wire mesh, and/or rebar at the proposed locations prior to installation of the subslab soil vapor probes. The subcontractor will use a concrete scanner which is a hand-held ground-penetrating radar (GPR) designed for use on concrete slabs. A visual survey will also be completed to identify areas where utilities come into the building, and building owners will be asked if they are aware of radiant floors.

Subslab Soil Vapor Probe Installation

Subslab soil vapor probe installation will be performed in accordance with FOP-08 *Installation and Abandonment of Vapor Pins as Subslab Soil Vapor Probes* after the utility clearance is completed.

The exact locations of the subslab soil vapor probes will be selected during the building survey with permission from the property owner. Ideally, the subslab soil vapor probes will be spread throughout the slab to achieve spatial coverage with one located in the center of the building and one biased towards the side of the building closest to the plume or presumed source facility; however, building owner preference and avoiding damage to floor coverings will take precedence. The number of subslab soil vapor probes will be dependent on the square footage of the building footprint:

- Up to 1,500 square feet (ft^2) – 2 Subslab Probes
- 1,501 to 5,000 ft^2 – 3 Subslab Probes
- 5,001 to 10,000 ft^2 – 4 Subslab Probes
- 10,001 to 20,000 ft^2 – 5 Subslab Probes
- 20,001 to 50,000 ft^2 – 6 Subslab Probes
- 50,001 to 250,000 ft^2 – 8 Subslab Probes

The following criteria will be used when selecting locations to install subslab soil vapor probes:

- If multiple foundation types are present in the building, or if the slab was poured at different times, one subslab soil vapor probe will be installed in each "type" of foundation present. If more foundation types are present than planned subslab soil vapor probes in a building, then the probes will be installed in the types of foundation closest to the soil vapor plume.
- If a building has a partial slab and partial basement dirt floor, then indoor air samples will be collected in the dirt floor area instead of subslab soil vapor samples. However, if the building has a full dirt floor, then no subslab soil vapor probes will be installed, and indoor air samples will be collected in the dirt floor area. These indoor air samples will be in addition to those already planned for the building.
- If crawlspaces are identified in a building, then crawlspace air samples will be collected instead of subslab soil vapor samples in that portion of the building. The exact number of crawlspace air and/or subslab soil vapor samples to be collected at each property will be determined in the field.
- Subslab soil vapor probes should be placed at least 5 feet away from exterior walls and penetrations in the slab (large cracks, sumps, drains, utilities, and so forth) to avoid short-circuiting of ambient air.
- If the basement or ground level where the subslab soil vapor probes are being installed is divided into separate compartments and/or HVAC zones, then attempts will be made to collect subslab soil vapor samples from the separate areas as feasible.

Permanent subslab soil vapor probes will be installed by drilling a hole through the concrete slab using a hammer drill and inserting a Cox-Colvin & Associates, Inc., Vapor Pin into the hole. A flush-mount stainless-steel cover will be installed to cover the probe.

Subslab Soil Vapor, Crawlspace Air, Indoor Air, and Outdoor Air Sampling

Indoor air and/or crawlspace air samples will be collected concurrently within each building. The building will be re-screened with a ppb-RAE before setting up the sample canisters to make sure there are no new indoor VOC sources/products. If additional products are found, then sampling at that property may be rescheduled if the product contains VOCs on the site-specific analyte list. The decision to reschedule sampling will be assessed in the field with phone input as necessary from the subject matter experts and/or senior technical consultant.

Subslab soil vapor probes will be purged, leak-checked, and sampled in accordance with FOP-09 *Subslab Soil Vapor Sampling from Vapor Pins.* Each subslab soil vapor probe will be leak-checked using the Cox-Colvin water dam method prior to sampling.

Crawlspace air, indoor air, and outdoor air samples will be collected the FOP-10 *Indoor, Outdoor, and Crawlspace Air Sampling Using Canisters*. One crawlspace air sample will be collected from each accessible crawlspace at a building, if present.

Indoor air samples will generally be collected at each residential or industrial/commercial building according to the square footage of each building footprint:

- Up to 5,000 ft^2 – 2 Indoor Air Samples
- 5,001 to 10,000 ft^2 – 3 Indoor Air Samples
- 10,001 to 20,000 ft^2 – 4 Indoor Air Samples
- 20,001 to 50,000 ft^2 – 5 Indoor Air Samples
- 50,001 to 250,000 ft^2 – 6 Indoor Air Samples

However, if the building has a large warehouse area, then a lesser number of indoor air samples may be collected because indoor air sampling will be focused on office spaces and other frequently occupied areas. Additionally, if there is documented use of the site-specific COCs, then indoor air sampling will not be performed.

For structures with basements, indoor air samples will be collected from the basement and the first floor if the first floor is occupied. Sampling locations should be toward the center of the structure and not adjacent to windows or exterior walls, if possible. The locations of the indoor air samples will be selected based upon the results of the building survey. When feasible, indoor air samples will be placed near areas where higher indoor air VOC concentrations were measured during the ppb-RAE screening that were not potentially related to confounding indoor VOC sources. When feasible, indoor air sample canisters will be placed within the breathing zones, and away from windows, air ducts, and potential confounding indoor air sources.

Two outdoor air samples will be collected per day of subslab soil vapor, crawlspace air, and indoor air sampling. Outdoor air samples will be placed in the vicinity of the properties being sampled, in an upwind location. High-traffic areas will be avoided, if possible, when selecting outdoor air sample locations. Furthermore, the outdoor air samples will be collected in locations that the field team determines are representative of general outdoor air conditions near the properties being sampled that day (and generally upwind of the area being sampled).

Indoor air, and outdoor air, and crawlspace air samples will be collected in individually certified 6-liter evacuated canisters a period of approximately 24 hours for residential buildings and 8 hours for industrial/commercial buildings. Soil vapor and subslab samples will be collected in batch certified 1-liter canisters over a period of approximately 5 minutes for residential buildings and industrial/commercial buildings. Samples will be submitted to the subcontracted laboratory, ALS Global, for analysis following the analytical SOP (Appendix B). Subslab soil vapor samples will be analyzed for site-specific COCs by EPA Method TO-15. Indoor, outdoor, and crawlspace air samples be analyzed for site-specific COCs by EPA Method TO-15-SIM. Samples will be shipped to the following ALS Global location:

ALS Global
Kate Kaneko
2655 Park Center Drive, Suite A
Simi Valley, CA 93065

Round 2 of Interior Vapor Intrusion Sampling

A second round of interior VI sampling and outdoor air sampling will be performed approximately 6 months after the first round at buildings where the first round of indoor air samples had measured concentrations below the EPA RMLs, or indoor air concentrations above the RMLS were not related to VI. One of the two sampling rounds will be performed in the heating season. The same locations at each building will be resampled. The subslab soil vapor probes will remain in place after Round 1 so they will not need to be re-installed. Sample procedures will be identical to those completed during the Round 1 sampling event.

Building occupants will be asked to remove the same potential indoor VOC sources identified in Round 1 prior to sampling. The building survey will be reviewed and the building re-screened with a ppb-RAE before setting up the sample canisters to make sure there are no new chemical sources/products that may be confounding indoor VOC sources.

Worksheet #18—Sampling Locations and Methods

Two separate investigations will be performed at the site for this project as follows:

- **Soil vapor plume delineation northeast and east of the Behr facility** - Exterior soil vapor sampling will be performed in the groundwater VISL plume area north and east of the Behr facility where groundwater concentrations are relatively lower to delineate the soil vapor plume (PCE, TCE, cis-1,2-DCE, 1,1,1-TCA, and VC) as discussed in **Worksheet #17**. Temporary exterior soil vapor probes will be installed and sampled at up to 32 locations (Figure 2). The soil vapor probe screens will be placed approximately 3 to 5 feet above the groundwater table, which will be determined from historical groundwater elevation information and up to 10 soil borings. Additionally, dual-depth probes, with the shallow screen approximately 5 to 6 feet bgs, will be installed at four of the up to 32 locations.
- **Interior VI sampling southwest of the Behr facility** - Interior VI sampling will be performed at occupied buildings selected by EPA located within the Behr Dayton Thermal VOC groundwater VISL plume that have not yet been sampled. The interior VI sampling will include performing building surveys and collecting interior VI samples (indoor air, and subslab soil vapor and/or crawlspace air) and outdoor air samples as discussed in **Worksheet #17**. It is assumed that interior VI sampling will be performed at up to 15 buildings for planning purposes. A second round of interior VI sampling will be performed approximately 6 months after Round 1 at buildings where the first round of samples had measured concentrations below the EPA RMLs. It is assumed that a second round of interior VI sampling will be performed at eight of the 15 buildings for planning purposes.

Sampling Location/ID Number	Matrix	Depth (feet below ground surface)	Analytical Group	Concentration Level	Number of Samples (identify field duplicates)	Sampling FOP Reference[a]	Rationale for Sampling Location
Soil vapor plume delineation northeast and east of the Behr facility							
BR-HAP-XXX-DATE	HAPSITE Exterior Soil Vapor	Soil vapor probe screens will be places 3 to 5 feet above the groundwater table which will be determined based on historical groundwater depths and soil types and the groundwater depths and soil types observed in the up to 10 soil borings	PCE, TCE, cis-1,2-DCE, 1,1,1-TCA, and VC (HAPSITE GS/MS)	Unknown	36 (4)	FOP-04, and -05	Delineate the soil vapor plume in the groundwater VISL plume area northeast and east of the Behr facility.
BR-HAP-XXX-DATE-C	HAPSITE Confirmation Exterior Soil Vapor	Soil vapor probe screens will be places 3 to 5 feet above the groundwater table, which will to be determined based on historical groundwater depths and soil types, and the groundwater depths and soil types observed in the 10 soil borings	TO-15 (Confirmation Samples) *	Unknown	4 (1)	FOP-04	Delineate the soil vapor plume in the groundwater VISL plume area northeast and east of the Behr facility. Confirmation samples will be selected in the field to encompass a range of concentrations observed with the HAPSITE.
Interior VI sampling south and west of the Behr facility – Round 1							
BR-XX-XXX-SS-XXX-MMDDYY	Subslab Soil Vapor	Shallow – below building slab	TO-15*	Unknown	45 (plus 5 duplicates)	FOP-09	To evaluate the potential for complete and significant VI pathways at occupied buildings.
BR-XX-XXX-IA-XXX-MMDDYY	Indoor Air	NA	TO-15 SIM*	Trace to low	30 (plus 3 duplicates)	FOP-10	To evaluate the potential for complete and significant VI pathways at occupied buildings.

Sampling Location/ID Number	Matrix	Depth (feet below ground surface)	Analytical Group	Concentration Level	Number of Samples (identify field duplicates)	Sampling FOP Reference[a]	Rationale for Sampling Location
BR-XX-XXX-OA-XXX-DATE(MMDDYY)	Outdoor Air	NA	TO-15 SIM*	Trace to low	9 (plus 1 duplicates)	FOP-10	To evaluate the potential for outdoor VOC sources contributing to measured indoor air VOC concentrations.
BR-XX-XXX-CS-XXX-MMDDYY	Crawlspace Air	NA	TO-15 SIM*	Trace to low	Unknown	FOP-10	To evaluate the potential for complete and significant VI pathways at occupied buildings.
Interior VI sampling south and west of the Behr facility – Round 2							
BR-XX-XXX-SS-XXX-MMDDYY	Subslab Soil Vapor	Shallow – below building slab	TO-15*	Unknown	24 (plus 3 duplicates)	FOP-09	To evaluate the potential for complete and significant VI pathways at occupied buildings.
BR-XX-XXX-IA-XXX-MMDDYY	Indoor Air	NA	TO-15 SIM*	Trace to low	16 (plus 2 duplicates)	FOP-10	To evaluate the potential for complete and significant VI pathways at occupied buildings.
BR-XX-XXX-OA-XXX-MMDDYY	Outdoor Air	NA	TO-15 SIM*	Trace to low	3 (plus 1 duplicates)	FOP-10	To evaluate the potential for outdoor VOC sources contributing to measured indoor air VOC concentrations.
BR-XX-XXX-CS-XXX-MMDDYY	Crawlspace Air	NA	TO-15 SIM*	Trace to low	Unknown	FOP-10	To evaluate the potential for complete and significant VI pathways at occupied buildings.

*** -** Site-specific COC list

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Worksheets #19 and #30—Analytical SOP Requirements Table

Matrix	Analytical Group	Concentration Level	Analytical and Preparation Method/SOP Reference[a]	Containers (number, size, and type)	Preservation Requirements	Maximum Holding Time (preparation/analysis)	Data Package Turnaround
Environmental Samples							
Soil vapor and air samples	VOCs	Unknown to Low	Lab SOP #1, #2 and #13	1-liter or 6-liter canister	None	28 days	7 days Preliminary 21 days Final
External deep and shallow soil gas	VOCs	Hight to low	FOP#5	1 liter Tedlar bags	None	24 hours	Same day for preliminary, one week after completion of field event for final
Waste Characterization Samples							
IDW-Soil	TCLP VOCs	Low	Lab SOP #3 and #7, #13 and #14	4-ounce or larger wide-mouth glass jar, no head space	4 °C	14 days to TCLP, 14 days to analysis	14-day Preliminary 21-day Final
IDW-Soil	TCLP SVOCs	Low	Lab SOP #4, #5, #8, #13 and #14	4-ounce or larger wide-mouth glass jar, no head space	4 °C	14 days to TCLP, 7 days to extract, 40 days to analysis	14-day Preliminary 21-day Final
IDW-Soil	TCLP RCRA 8 Metals	Low	Lab SOP #5, #10, #11, #12, #13 and #14	4-ounce or larger wide-mouth glass jar	4 °C	14 days to TCLP, 180 days to digest and analyze (28 days for mercury)	14-day Preliminary 21-day Final
IDW-Soil	pH, Ignitability	Low	Lab SOP #6, #13, #14, and #15	4-ounce or larger wide-mouth glass jar	4 °C	As soon as possible	14-day Preliminary 21-day Final
IDW-Aqueous	VOCs	Low	Lab SOP #7, #13 and #14	3 x 40-mL glass vials	HCl to pH <2; 4 °C	14 days to analysis	14-day Preliminary 21-day Final
IDW-Aqueous	SVOCs	Low	Lab SOP #4, #8, #13 and #14	2 x 1-L amber glass	4 °C	7 days to extraction/ 40 days to analysis	14-day Preliminary 21-day Final
IDW-Aqueous	RCRA 8 Metals	Low	Lab SOP #10, #11, # 12, #13 and #14	500-mL plastic	HNO_3 to pH < 2, 4 °C	180 days (mercury, 28 days)	14-day Preliminary 21-day Final

Matrix	Analytical Group	Concentration Level	Analytical and Preparation Method/SOP Reference[a]	Containers (number, size, and type)	Preservation Requirements	Maximum Holding Time (preparation/analysis)	Data Package Turnaround
IDW-Aqueous	Flashpoint	Low	Lab SOP #9, #13 and #14	250-mL HDPE	4 °C	As soon as possible, 28 days	14-day Preliminary 21-day Final
IDW-Aqueous	pH/Corrosivity	Low	Lab SOP #6, #13 and #14				

[a] Specify the appropriate reference letter or number from the analytical SOPs table (**Worksheet #23**).

Worksheet #20—Field Quality Control Summary

Field Duplicate Samples

Field duplicates are two field samples taken concurrently at the same location. They are intended to represent the same population and are taken through all steps of the sampling and analytical procedures in the same manner as the associated native sample. The samples are used to assess the precision of the entire data collection activity, including sampling, sample handling and storage, and site heterogeneity but are not meant to replace or supersede the parent sample or sample delivery group to which they are attached. The field duplicates are assigned a unique sample name and are collected in a separate container from the associated native sample. One field duplicate will be collected for every 10 field samples (except for IDW characterization). During collection of the field duplicate samples of soil vapor, two evacuated canisters will be connected with a T-connector provided by the laboratory to allow for collection of the parent and duplicate sample at the same time. Field duplicates in Tedlar bags for HAPSITE analysis will be collected in quick succession after purging.

Field duplicate results will not be utilized in defining nature and extent, but will be used in the human health risk assessment calculations.

Trip Blanks

Trip blanks will be used to assess the potential introduction of contaminants to VOC sample containers during field events and during shipment of empty bottles to the site and samples to the laboratory. The trip blank consists of a VOC sample vial filled at the laboratory with laboratory grade deionized water. It is transported to the site in the same manner as the other sampling containers, stored with the samples in the field, and then returned to the laboratory for analysis. One trip blank will be included in each sample cooler containing VOC samples, if more than one VOC sample is collected for IDW analysis.

Air canisters will not be subject to trip blanks. Only one media will be shipped in any one cooler.

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Worksheet #20-1—Field Quality Control Summary Table

Matrix	Analytical Group	Concentration Level	Analytical and Preparation SOP Reference[a]	Number of Samples	Number of FDs	Number of MS/MSDs	Number of FB/EB/TB/AB	Total Number of Samples
Soil vapor plume delineation northeast and east of the Behr facility								
Soil Vapor	PCE, TCE, and 1,1,1-TCA (HAPSITE GS/MS)	Unknown	FOP-04 FOP -05	36	4	-	-	40
Soil Vapor	TO-15*	Unknown	Laboratory SOP #1 Laboratory SOP #2 Laboratory SOP #13	4	1	-	-	5
IDW-Soil	TCLP VOCs, TCLP SVOCs, TCLP metals, pH, and flashpoint	Low	Laboratory SOP #3 Laboratory SOP #5 Laboratory SOP #6 Laboratory SOP #7 Laboratory SOP #8 Laboratory SOP #10 Laboratory SOP #11 Laboratory SOP #12 Laboratory SOP #13 Laboratory SOP #14 Laboratory SOP #15	1	-	-	-	1
IDW- Aqueous	VOCs, SVOCs, RCRA 8 metals, pH	Low	Laboratory SOP #4 Laboratory SOP #6 Laboratory SOP #7 Laboratory SOP #8 Laboratory SOP #9 Laboratory SOP #10 Laboratory SOP #11 Laboratory SOP #12 Laboratory SOP #13 Laboratory SOP #14	1	-	-	1 TB	2
Interior VI sampling southwest of the Behr facility – Round 1								
Subslab Soil Vapor	TO-15*	Unknown	Laboratory SOP #1 Laboratory SOP #2 Laboratory SOP #13	45	5	-	-	50
Indoor Air	TO-15 SIM*	Low		30	3	-	-	33
Outdoor Air	TO-15 SIM*	Low		9	1	-	-	10
Crawlspace Air	TO-15 SIM*	Low		TBD	TBD	-	-	TBD

Matrix	Analytical Group	Concentration Level	Analytical and Preparation SOP Reference[a]	Number of Samples	Number of FDs	Number of MS/MSDs	Number of FB/EB/TB/AB	Total Number of Samples
Interior VI sampling southwest of the Behr facility – Round 2								
Subslab Soil Vapor	TO-15*	Unknown	Laboratory SOP #1 Laboratory SOP #2 Laboratory SOP #13	24	3	-	-	27
Indoor Air	TO-15 SIM*	Low		16	2	-	-	18
Outdoor Air	TO-15 SIM*	Low		3	1	-	-	4
Crawlspace Air	TO-15 SIM*	Low		TBD	TBD	-	-	TBD

[a] Specify the appropriate reference letter or number from the analytical SOPs table (**Worksheet #23**).

Notes:

**** -** Site-specific COC list*

TBD = To be determined in the field once building survey has been completed, crawlspace sample will take the place of a subslab sample

FD = field duplicate; TB = trip blank; MS = matrix spike; MSD = matrix spike duplicate; FB = field blank; EB = equipment blank; AB = ambient blank

Worksheet #21—Field Operating Procedures

Reference Number	Title, Revision, Date and/or Number	Originating Organization	Equipment Type	Modified for Project Work? (Check if yes)	Comments
FOP-01	Utility Clearance for Intrusive Operations	CH2M	Detailed in the FOP	☐	
FOP-02	Soil Boring Logging	CH2M	Detailed in the FOP	☐	
FOP-03	Installation and Abandonment of Temporary Exterior Soil Vapor Probes	CH2M	Detailed in the FOP	☐	
FOP-04	Soil Vapor Sampling from Exterior Soil Vapor Probes	CH2M	Detailed in the FOP	☐	
FOP-05	Determination of Volatile Organics in Soil Vapor Using the HAPSITE Field GC/MS	CH2M	Detailed in the FOP	☐	
FOP-06	Equipment Decontamination	CH2M	Detailed in the FOP	☐	
FOP-07	Conducting Building Surveys for VI Investigations	CH2M	Detailed in the FOP	☐	
FOP-08	Installation and Abandonment of Vapor Pins as Subslab Soil Vapor Probes	CH2M	Detailed in the FOP	☐	
FOP-09	Subslab Soil Vapor Sampling from Vapor Pins	CH2M	Detailed in the FOP	☐	
FOP-10	Indoor, Outdoor, and Crawlspace Air Sampling Using Canisters	CH2M	Detailed in the FOP	☐	
FOP-11	Sample Handling and Chain-of-Custody Procedures	CH2M	Detailed in the FOP	☐	
FOP-12	Packing and Shipping of Environmental Samples	CH2M	Detailed in the FOP	☐	
FOP-13	Note Taking and Field Logbook	CH2M	Detailed in the FOP	☐	

Worksheet #22—Field Equipment Calibration, Maintenance, Testing, and Inspection

Field Equipment	Calibration Activity	Maintenance Activity	Testing Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference[a]
Photoionization Detector	Calibrate with standards.	Model-specific, per manufacturer's recommendation.	Soil Screening, Air Monitoring	Daily	Model specific, per manufacturer's recommendation.	As needed per SOP.	Field Team Leader	Model- and manufactur er- specific
Combustible Gas/Oxygen/Hydroge n Sulfide Monitors	Calibrate with standards.	Model-specific, per manufacturer's recommendation.	Air Monitoring	Daily	Model specific, per manufacturer's recommendation.	As needed per SOP.	Field Team Leader	Model- and manufactur er- specific
Helium Detector	Bump Check with 10% helium gas (factory calibration only).	Charge batteries. Allow the batteries to totally discharge before recharging to prevent battery memory from occurring. Perform maintenance per manufacturer's instructions.	Leak check of subslab probe and tubing	Daily before use	±5% of bump check gas	If meter fails to calibrate correctly, do not use this meter.	Field Team Leader	FOP-04, model- and manufactur er- specific
LandTec GEM Landfill Gas Meter	Check fresh air levels to confirm they are within the typical range.	Perform maintenance per manufacturer's instructions.	Field screen soil vapor for oxygen, carbon dioxide, and methane.	Daily before use	±5% of typical air concentrations	If meter fails to calibrate correctly, do not use this meter.	Field Team Leader	FOP-04, model- and manufactur er- specific
HAPSITE gas chromatograph/mass spectrometer	Initial Calibration (IC)	NA	5-point initial calibration. Low point at or below reporting limit.	Prior to sample analysis	Percent RSD ≤ 30 or linear ≤0.995	Correct problem then repeat IC Curve.	Field Chemist	FOP-05

Field Equipment	Calibration Activity	Maintenance Activity	Testing Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference[a]
	Calibration Verification (CV)	NA	Verification of accuracy of calibration curve	At the start and end of each day	70-130 percent	Perform maintenance and repeat test. If the system still fails the CV, perform a new initial calibration. For closing CV, flag data.	Field Chemist	FOP-05
	Method Blank	NA	Check for instrument contamination	At the start and of each day.	No analytes detected > RL.	Correct problem. Re-prep and reanalyze blank.	Field Chemist	FOP-05
	Maintenance	As outlined in the manufacturer's instruction manual.	NA	Proper storage during inactive periods	NA	Follow procedure as outlined in the manufacturer's instruction manual or contact vendor technical support.	Field Chemist	FOP-05

[a] Refer to the project SOPs table (**Worksheet #21**).

Worksheet #23—Analytical SOPs

Reference Number	Method	Title, Revision Number and Date	Definitive or Screening Data	Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work?
Lab SOP #1	EPA TO-15/TO-15 SIM	Determination of Volatile Organic Compounds in Air Samples Collected in Specially Prepared Canisters and Gas Collection Bags By Gas Chromatography/Mass Spectrometry (GC/MS), Rev. 23, 4/30/2016	Definitive	TO-15 (Air)	GC/MS	ALS Global, Simi Valley	☐
Lab SOP #2	N/A	Cleaning and Certification of Summa Canisters and Other Specially Prepared Canisters, Rev. 17, 11/21/2015	Definitive	TO-15 (Air)	GC/MS	ALS Global, Simi Valley	☐
Lab SOP #3	SW-846 1311	Toxicity Characteristic Leaching Procedure – Zero Headspace Extraction, Rev. 05, 3/15/2017	Definitive	TCLP VOCs (IDW)	N/A	ALS Global, Simi Valley	☐
Lab SOP #4	SW-846 8270 B/C	Liquid – Liquid Extraction (Separatory Funnel), Rev. 12, 8/31/2016	Definitive	SVOCs (IDW)	Separatory Funnel	ALS Global, Simi Valley	☐
Lab SOP #5	SW-846 1311	Toxicity Characteristic Leaching Procedure – Non-Volatile Extraction, Rev. 08, 10/15/2016	Definitive	TCLP (IDW)	N/A	ALS Global, Simi Valley	☐
Lab SOP #6	SW-846 9040C, 9045D	pH Measurement, Rev. 08, 9/15/2016	Definitive	pH (IDW)	pH meter	ALS Global, Simi Valley	☐
Lab SOP #7	SW-846 8260B	Volatile Organic Compounds, Rev. 07, 8/3/2015	Definitive	VOCs (IDW)	GC/MS	ALS Global, Simi Valley	☐
Lab SOP #8	SW-846 8270D	Semi-Volatile Organic Compounds, Rev. 08, 9/15/2016	Definitive	SVOCs (IDW)	GC/MS	ALS Global, Simi Valley	☐
Lab SOP #9	SW-846 1010	Flash Point by Pensky-Martens Closed Cup, Rev. 07, 8/31/2016	Definitive	Flashpoint (IDW)	Thermometer	ALS Global, Simi Valley	☐
Lab SOP #10	SW-846 6010C	Metals by ICP-AES, Rev. 02, 8/31/2016	Definitive	RCRA 8 Metals (IDW)	ICP-AES	ALS Global, Simi Valley	☐
Lab SOP #11	SW-846 7470A	Mercury – Aqueous, Rev. 10, 8/31/2016	Definitive	Mercury (IDW)	CVAA	ALS Global, Simi Valley	☐
Lab SOP #12	SW-846 3005A	Metals Aqueous Digestion, Rev. 09, 12/31/2016	Definitive	RCRA 8 Metals (IDW)	Hot Block Digester	ALS Global, Simi Valley	☐
Lab SOP #13	N/A	Sample Receiving, Acceptance, And Login, Rev. 17, 4/29/2017	Definitive	VOCs (Air) and IDW	N/A	ALS Global, Simi Valley	☐

Reference Number	Method	Title, Revision Number and Date	Definitive or Screening Data	Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work?
Lab SOP #14	N/A	Waste Disposal, Rev. 14, 6/25/2016	Definitive	IDW	N/A	ALS Global, Simi Valley	☐
Lab SOP #15	SW-846 1030	Ignitability, Rev 6, 11/30/2016	Definitive	IDW	Stopwatch	ALS Global, Simi Valley	☐

Notes:

GC/MS = gas chromatograph/mass spectrometry, ICP-AES =inductively coupled plasma-atomic emission spectroscopy, CVAA = cold vapor atomic absorption, TCLP = toxicity characteristic leaching procedure, N/A = not applicable

Worksheet #24—Analytical Instrument Calibration

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference[a]
GC/MS (for VOCs in Soil Vapor Air)	Initial Calibration (IC)	Instrument receipt, instrument change (new column, source cleaning, etc.), when continuing calibration verification (CCV) is out of criteria.	Five-point curve - The percent relative standard deviation (%RSD) for all analytes must be ≤ 30%, with at most two exceptions up to a limit of 40%.	Repeat calibration if criterion is not met.	Analyst	Laboratory SOP #1, #2
	Initial Calibration Verification (ICV)	Once after each IC.	All analytes within 65-135%R.	Correct problem, rerun ICV. If that fails, repeat IC.		
	Continuing Calibration Verification (CCV)	Daily.	All project analytes within ± 30% of true value with 1 marginal exceedance of ± 40%.	Correct problem, rerun CCV. If that fails, repeat IC.		
	BFB Tune	Every 24 hours.	Refer to method for specific ion criteria.	Retune and/or clean source.		
GC/MS (for VOCs)	IC	Instrument receipt, instrument change (new column, source cleaning, etc.), when CCV is out of criteria.	Five-point curve - The average RFs for system performance check compounds (SPCCs) must be ≥ 0.30 for chlorobenzene and 1,1,2,2-tetrachlorobenzene and ≥ 0.10 for chloromethane, 1,1-dichloroethane and bromoform. The %RSD for RFs for calibration check compounds (CCCs) must be ≤ 30%, and one option below must be met: Option 1) %RSD ≤ 15% for all other compounds. If not met: Option 2) Linear least squares regression: correlation coefficient (r) ≥ 0.995. Option 3) Non-linear regression: coefficient of determination (r^2) ≥ 0.99 (6 points for second order).	Repeat calibration if criterion is not met.	Analyst	Laboratory SOP #7

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference[a]
	ICV	Once after each IC.	All project analytes within ± 20% of true value.	Correct problem and verify second source standard. Rerun second source verification. If that fails, correct problem and repeat IC.		
	CCV	At the beginning of each 12-hour shift immediately after BFB tune.	1) Average RF for SPCCs: VOCs ≥ 0.30 for chlorobenzene and 1,1,2,2-tetrachloroethane; ≥ 0.1 for chloromethane, bromoform and 1,1-dichloroethane. 2) %Difference/Drift for all target compounds and surrogates: VOCs ≤ 20%D (Note, D = Difference when using RFs, D = Drift when using least squares regression or non-linear calibration.)	Repeat IC and reanalyze all samples analyzed since the last successful calibration verification.		
	BFB Tune	Every 12 hours.	Refer to method for specific ion criteria.	Retune and/or clean source.		
	Retention time window position establishment	Once after each IC for each analyte and surrogate.	Position shall be set using the midpoint standard of the IC curve when IC is performed. On days when IC is not performed, the initial CCV is used.	N/A		
	Evaluation of relative retention times (RRT)	With each sample.	RRT of each target analyte within ± 0.06 RRT units.	Correct problem, then rerun IC. Flagging criteria are not appropriate.		
GC/MS (for SVOCs)	ICAL	Instrument receipt, instrument change (new column, source cleaning, etc.), when CCV is out of criteria.	Five-point curve – The average RF for SPCCs must be ≥ 0.050; The %RSD for RFs for CCCs must be <30%, and one option below must be met: Option (1) %RSD ≤ 15% for all other compounds. If not met: Option (2) Linear least squares regression: r ≥ 0.995. Option (3) Non-linear regression: $r^2 \geq 0.99$ (6 points for second order).	Repeat calibration if criterion is not met.	Analyst	Laboratory SOP #8

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference[a]
	ICV	Once after each IC.	All analytes within ± 20% of the expected value.	Correct problem and verify second source standard. Rerun second source verification. If that fails, correct problem and repeat IC.		
	CCV	At the beginning of each 12-hour shift immediately after DFTPP tune.	1) Average RF for SPCCs: SVOCs ≥ 0.050 2) %Difference/Drift for all target compounds and surrogates: VOCs ≤ 20%D (Note, D = Difference when using RFs, D = Drift when using least squares regression or non-linear calibration.)	Repeat IC and reanalyze all samples analyzed since the last successful calibration verification.		
	DFTPP Tune	Every 12 hours.	Must meet the ion abundance criteria required by the method.	Retune and/or clean source.		
	Retention time window position establishment	Once after each IC for each analyte and surrogate.	Position shall be set using the midpoint standard of the ICAL curve when IC is performed. On days when IC is not performed, the initial CCV is used.	N/A		
	Evaluation of RRT	With each sample.	RRT of each target analyte within ± 0.06 RRT units.	Correct problem, then rerun IC. Flagging criteria are not appropriate.		
ICAP (metals)	IC	Instrument receipt, major instrument change, when CCV does not meet criteria.	Minimum one high standard and a calibration blank for all analytes. If more than one calibration standard is used, correlation coefficient ® ≥ 0.995 (r^2>0.990).	Correct problem, then repeat IC. Flagging criteria are not appropriate.	Analyst	Laboratory SOP #10
	ICV	Once after each IC, prior to beginning a sample run.	All analytes within 90 to 110 %R.	Correct problem and verify second source standard. Rerun ICV. If that fails, correct problem and repeat IC. Flagging criteria are not appropriate.		

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference[a]
	CCV	After every 10 field samples and at the end of the analysis sequence.	All analytes within 90 to 110 %R.	Correct problem, rerun CCV. If that fails, then repeat IC. Reanalyze all samples since the last successful CCV.		
	Linear dynamic range or high-level check standard	Every 6 months	Within ±10% of true value.	N/A		
	Low-level calibration check standard	Daily, after 1-point IC.	Within ±20% of true value.	Correct problem, then reanalyze. Flagging criteria are not appropriate.		
	Calibration Blank	Before beginning a sample run, after every 10 samples, and at end of the analysis sequence.	No analytes detected > MDL.	Correct problem. Re-prep and reanalyze calibration blank. All samples following the last acceptable calibration blank must be reanalyzed.		
	Interference check solutions (ICSs)	After beginning of the analytical run.	ICS-A: Absolute value of concentration for all non-spiked analytes < MDL ICS-AB: Within 20% of true value	Terminate analysis; locate and correct problem; reanalyze ICS, reanalyze all samples.		
CVAA (for mercury)	IC	Instrument receipt, major instrument change, at the start of each day.	Five-point curve. If more than one calibration standard is used, correlation coefficient(r) ≥ 0.995 (r^2>0.990).	Correct problem, then repeat IC. Flagging criteria are not appropriate.	Analyst	Laboratory SOP #11
	ICV	Once after each IC, prior to beginning a sample run.	All analytes within 80 to 120 %R.	Correct problem and verify second source standard. Rerun ICV. If that fails, correct problem and repeat IC. Flagging criteria are not appropriate.		
	CCV	After every 10 field samples and at the end of the analysis sequence.	All analytes within 80-120 %R.	Correct problem, rerun CCV. If that fails, then repeat IC. Reanalyze all samples since the last successful CCV.		

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference[a]
	Calibration Blank	Before beginning a sample run, after every 10 samples, and at end of the analysis sequence.	No analytes detected > MDL.	Correct problem. Re-prep and reanalyze calibration blank. All samples following the last acceptable calibration blank must be reanalyzed.		

[a] Specify the appropriate reference letter or number from the Analytical SOP References table (**Worksheet #23**).

Notes:

GC/MS = gas chromatograph/mass spectrometry, ICAP = inductively coupled argon plasma, CVAA = cold vapor atomic absorption, SPCC = system performance check compound, IC = initial calibration, ICS-A = interference check sample A ; ICS-AB = interference check sample AB ;ICV = initial calibration verification, CCV = continuing calibration verification, DFTPP = decafluorotriphenylphosphine, BFB = 4-bromoflurobenzene, %D = percent drift, RRT = relative retention time, %RSD = percent relative standard deviation, RF = response factor, CCC = calibration check compounds, ICS = interference check solution

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Worksheet #25—Analytical Instrument and Equipment Maintenance, Testing, and Inspection

☑ Worksheet Not Applicable (State Reason)

The subcontract laboratory will keep all maintenance, testing, and inspection records on file at the laboratory. The instrument and equipment maintenance, testing, and inspection activities are documented per the SOPs listed in **Worksheet #23**. If requested, a reference attachment from the subcontract laboratory's Quality Manual will be included in the final QAPP once the laboratory has been procured.

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference[a]

[a] Specify the appropriate reference letter or number from the analytical SOPs table (**Worksheet #23**).

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Worksheets #26 and #27—Sample Handling, Custody, and Disposal

Sample Collection, Packaging, and Shipment
Sample Collection (Personnel/Organization): Field team leader/CH2M
Sample Packaging (Personnel/Organization): Field team leader/CH2M
Coordination of Shipment (Personnel/Organization): Field team leader/CH2M
Type of Shipment/Carrier: Federal Express Overnight
Sample Receipt and Analysis
Sample Receipt (Personnel/Organization): Laboratory
Sample Custody and Storage (Personnel/Organization): Laboratory
Sample Preparation (Personnel/Organization): Laboratory
Sample Determinative Analysis (Personnel/Organization): Laboratory
Sample Archiving
Field Sample Storage (No. of days from sample collection): See QAPP **Worksheet #19** for allowable holding time
Sample Extract/Digestate Storage (No. of days from extraction/digestion): See QAPP **Worksheet #19** for allowable holding time
Sample Disposal
Personnel/Organization: Laboratory
Number of Days from Analysis: The laboratory will retain samples for at least 90 days and sample extracts for at least 30 days, after submittal, pending the need for reanalysis.

Field Sample Custody Procedures (sample collection, packaging, shipment, and delivery to laboratory)

Sample handling and chain-of-custody procedures will be performed in accordance with FOP-11 *Sample Handling and Chain-of-Custody Procedures*, and packaging and shipping of environmental samples will be performed in accordance with FOP-12 *Packing and Shipping of Environmental Samples*.

For the IDW sampling, the sample coolers will be shipped to arrive at the laboratory the morning after sampling (priority overnight). The laboratory will be notified of the sample shipment and the estimated date of arrival of the samples being delivered.

For the air and soil vapor sampling, the samples will be shipped in boxes provided by the laboratory and will be shipped for priority overnight delivery. Regulations for packaging, marking/labeling, and shipping of hazardous materials and wastes are promulgated by the U.S. Department of Transportation. Air carriers that transport hazardous materials, in particular Federal Express, require compliance with the current edition of the International Air Transport Association Dangerous Goods Regulations, which applies to shipment and transportation of hazardous materials by air carrier. Following current

International Air Transport Association regulations will ensure compliance with U.S. Department of Transportation regulations**.**

Laboratory Sample Custody Procedures (receipt of samples, archiving, and disposal)

Upon sample receipt, the laboratory sample custodian will verify package seals, open the packages, check temperature blanks, record temperatures, verify sample integrity, and inspect contents against chain-of-custody forms. The project chemist will be contacted to seek resolution of any discrepancies between sample containers and chain-of-custody forms through contract-defined channels of communication. Once the shipment and chain-of-custody form are in agreement, the sample custodian will initiate an internal chain-of-custody form, as well as supply the laboratory task manager with a sample acknowledgement letter. When applicable, sample preservation will be checked and pH documented. If the sample temperatures are outside the required range, the laboratory will contact the project chemist as to the proper course of action. Air and soil vapor sample canister vacuums will be checked upon receipt and the vacuum readings will be provided to the project chemist.

Samples will be logged in and assigned a unique laboratory number for each sample, and the number will be used by all laboratory personnel handling samples to ensure all sample information is captured. Analyses required will be specified by codes assigned to samples at login. Labels containing the laboratory sample number are generated and placed on sample bottles.

After the laboratory labels the samples, they will be moved to an appropriate storage area including refrigerators where they will be maintained at 4 ± 2 degrees Celsius, when required.

When the analyst is ready to prepare and/or analyze the sample(s), an appropriate member of the sample management department will locate the sample(s), sign and date the internal sample tracking form, and provide the sample(s) to the analyst. When the analyst is finished with the sample(s), unused portions will be returned to an appropriate member of the sample management department for replacement in a secure storage. The analyst will sign and date internal chain-of-custody forms. In the event that entire samples are depleted during analysis, a notation of “sample depleted” or “entire sample used” will be written on the internal chain-of-custody forms.

Samples will be stored in designated secure storage areas. Samples and sample extracts will be maintained in a secure storage until disposal. No samples or extracts will be disposed of without prior written approval from an appropriate member of the project team. The sample custodian will note the sample disposal date in the sample ledger. The laboratory will dispose of samples in accordance with applicable regulations. Air samples will be held until the project chemist has reviewed preliminary data for any discrepancies that may cause the sample to be reanalyzed, upon request from the laboratory for sample disposal of specific cans the project chemist will approve or deny request based on data observations.

Documentation will be placed in a single, secured project file maintained by the laboratory project manager. The file will consist of the following components: agreements, correspondence, memorandums, notes, and data.

Reports (including QA reports) will be filed with correspondence. Analytical laboratory documentation, field data, and notes will be filed with the laboratory data. Filed materials may only be removed by authorized personnel on a temporary basis. The name of the person removing the file will be recorded. Laboratories will retain project files and data packages for 5 years, unless otherwise agreed.

Sample Identification Procedures

A sample numbering system will be used to identify each sample, including duplicate samples. The sample number will be a unique identifier.

Each sample, regardless of analytical protocol, will also be assigned a CH2M site-specific identifier, which will contain a site- and sample-specific location identifier that indicates where the sample was obtained.

The sample number and station location identifier will be included on the sample tag, the traffic report, and the chain-of-custody record.

The site-specific identifier is based on the following system:

- **Site**—BD (Behr Dayton).
- **Property Identifier**— The property identifier is the unique name defining if the property is residential (RP) or a commercial/Industrial property (CP). Immediately following the sampling location type is the unique property location identifier three-digit number that indicates the properties address.
- **Station Location**—The station location identifier is the unique name of the sampling location (for soil vapor “SV”, subslab “SS”, indoor air “IA”, outdoor air “OA”, crawlspace “CS”). Immediately following the sampling location type is the unique sampling location identifier three-digit number that indicates exactly where the sample was collected. The dual-depth soil vapor points will have two separate three-digit numbers.
- **Date**—Samples IDs will end with a six-digit date, with two digits for the month, two digits for the day, and two digits for the year (MMDDYY).
- HAPSITE samples w will be identified by “HAP” followed by a three-digit number based on the order the sample was collected in the field.
  - HAP-001 is the first HAPSITE sample collected in the field.
- HAPSITE confirmation samples will be identified by site-HAP-number of the correlation HAPSITE sample-date (MMDDYY)
  - BD-HAP-001-052217 is the confirmation sample of HAPSITE sample 001 collected on May 22, 2017.
- **Waste Samples**—The waste samples will be identified ”IDW” followed by a three-digit unique identifying number ending with a six-digit date.
- **QC Samples**—Blind field duplicates will be submitted for all sample media in the format “BD-XX-XXX-XX-FD-XXX-MMDDYY”. Trip blanks will have a “TB” identifier followed by the sample date. MS/MSDs are not identified in the station location identifier, but on the tag and the chain-of-custody form. QC samples will be sequentially numbered starting at “-001” for each day per station location, and a record of those assigned will be kept in the field logbook, sample processing log and Scribe.

Examples

- BD-CP-123-SS-001-052417 is the first subslab sample collected at commercial property 123 on May 24, 2017.
- BD-CP-123-SS-FD-001-052417 is the first subslab field duplicate collected with sample BD-CP-123-SS-001-052417 at the commercial property 123.

- BD-CP-123-IA-004-052417 is the fourth indoor air sample collected at the commercial property 123.
- BD-CP-123-IA-FD-001-052417 is the first indoor air field duplicate collected with sample BD-CP-123-IA-004-052417 at the commercial property 123.
- BD-IDW-001-052617 is a waste sample collected on May 26, 2017.

Chain-of-Custody Procedures

Chains of custody will include, at a minimum, laboratory contact information, client contact information, sample information, and relinquished by/received by information in accordance with FOP-11 *Sample Handling and Chain-of-Custody Procedures*. Sample information will include sample identification, date and time collected, number and type of containers, preservative information, analysis method, and comments. The chain-of-custody will also have the sampler's name and signature. The chain-of-custody will link location of the sample from the field logbook and sample processing log through sample disposal by the laboratory. See Appendix A, FOP-11 *Sample Handling and Chain-of-Custody Procedures*, Attachment 2, for an example of a chain-of-custody form. The laboratory will use the sample information to populate the laboratory database for each sample.

Worksheet #28—Analytical Quality Control and Corrective Action

Matrix: Soil Vapor and Air

Analytical Group: TO-15 and TO-15 SIM

Analytical Method/SOP Reference: Laboratory SOP #1

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)
Performance Check	Prior to IC, CC, and every 24 hours	Must meet method criteria	Retune instrument and verify.	Laboratory analyst	
Method Blank	1 per 24-hr tune	No target compound ≥ ½ Reporting Limit	Correct problem, then re-prepare and analyze MB and all samples processed with the contaminated blank.	Laboratory analyst	Accuracy/Bias
Laboratory Duplicate	1/20 Samples	Concentration of reported analytes are > 5 times the RL in either sample and RPD > 25%. One sample result < RL and a difference of ±times the RL.	If sufficient sample is available, reanalyze samples. Qualify data as needed.	Laboratory analyst	Precision
LCS	1/Extraction Batch or 1 per 24-hr tune	70-130 % Recovery	Correct problem, then re-prepare and analyze the LCS and all samples in the affected analytical batch.	Laboratory analyst	Sensitivity
Internal Standard	Every sample, spiked sample, standard, and MB	Area within -50% to +100% of IC midpoint std.	Inspect mass spectrometer and GC for malfunctions; mandatory reanalysis of samples analyzed while system was malfunctioning.	Laboratory analyst	Precision
Surrogate Spike	Every sample, spiked sample, standard, and MB	Recovery within limits stated in method	Correct the problem and reanalyze sample.	Laboratory analyst	Accuracy/Bias

Notes:

IC = initial calibration, CC = continuing calibration, MB = method blank,
LCS = laboratory control sample, RPD = relative percent difference, GC = gas chromatography, RL = reporting limit

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Worksheet #29—Project Documents and Records

Sample Collection Documents and Records	Onsite Analysis Documents and Records	Offsite Analysis Documents and Records	Data Assessment Documents and Records	Other
Field Notes	Sample Receipt, Custody, and Tracking Records	Sample Receipt, Custody, and Tracking Records	Data Verification/Validation Reports	Project database for analytical and field data
Boring Logs	Equipment Calibration Logs	Narrative	Corrective Action Forms	Health and safety briefing information
Scribe Database	Equipment Maintenance, Testing, and Inspection Logs	Standard Traceability Logs		Staff health and safety records
Chain-of-Custody Records	Corrective Action Forms	Equipment Calibration Logs		
Air Bills	Reported Field Sample Results	Sample Preparation Logs		
Custody Seals	Telephone Logs	Run Logs		
Telephone Logs	Analysis Logs	Equipment Maintenance, Testing, and Inspection Logs		
Corrective Action Forms	HAPSITE Raw Data (stored electronically)	Corrective Action Forms		
		Reported Field Sample Results		
		Reported Results for Standards, QC Checks, and QC Samples		
		Instrument Printout (raw data) for Field Samples, Standards, QC Checks, and QC Samples		
		Data Package Completeness Checklists		
		Extraction/Cleanup Records		
		Raw Data (stored electronically)		
		QA Review Records		

Field notes and the field logbook will be completed as detailed in FOP-13 *Note Taking and Field Logbook*.

Electronic analytical data will be similar in format to that of the Contract Laboratory Program laboratory. The laboratory data package will be organized such that the analytical results are reported on a per-analytical-batch basis, unless otherwise specified. In addition to the summary data deliverable, a full-supporting raw data deliverable package is required from the laboratory. All data will be provided electronically as a PDF file. CH2M will provide data copies to EPA.

An EDD is also required for all data. The laboratory will provide CH2M with an EDD in the current EQuIS format. The data will undergo QA reviews prior to being loaded to the project database. Delivery time for data from the laboratory will vary based on project-specific data use.

Sample Tracking Program

The EPA Scribe program will be used for field documentation and generation of chains of custody. Refer to EPA Office of Solid Waste and Emergency Response 9240.0-44, EPA 540-R-07-06 Contract Laboratory Program Guidance for Field Samplers, dated July 2007.

Project-specific Deliverables

Offsite laboratory analytical data will be exported into a format consistent with the EDD format specified by EPA Region 5. Data will be submitted to EPA Region 5 in accordance with the requirements located here: http://www.epa.gov/region5superfund/edman/. Documentation and reports specified in this QAPP will be retained in Adobe PDF format.

Other data and deliverables (e.g., sample forms, evaluation summaries, etc.) will be discussed in the DMP, which will be submitted separately from this QAPP.

Worksheets #31, #32, and #33—Assessments and Correction Action

Assessments

Assessment Type	Frequency	Assessment Deliverable	Person(s) Responsible for Performing Assessment (Title and Organizational Affiliation)	Report Recipient(s) (Title and Organizational Affiliation)	Projected Delivery Date(s)
Field progress report	Daily	Summarizing email	Field team leader, CH2M	Brett Fishwild, site manager, CH2M	Daily during field activities
Data review and verification	For all analytical delivery packages	Email of deficiencies	Jaime Sutton, project chemist, CH2M	ALS Global Laboratory, QA officer	After arrival of data from the laboratory and during data verification activities
Data validation	Two total – One each after data are validated from Round 1 and Round 2	Data validation reports	Jaime Sutton, project chemist, CH2M	Erik Hardin, work assignment manager, EPA	21 days after receipt of analytical data from laboratory
Data evaluation	Two total - One each after data collected and validated from Phase 1 and Phase 2	Interim technical memorandums	Brett Fishwild, site manager, CH2M	Erik Hardin, work assignment manager, EPA	45 days after receipt of validated data
Data evaluation	One total, after Phase 1, 2, and 3 completion	RI report	Brett Fishwild, site manager, CH2M	Erik Hardin, work assignment manager, EPA	45 days after receipt of validated data

Assessments and Corrective Action

Assessment Type	Corrective Action Documentation	Person(s) Responsible for Identifying and Implementing Corrective Actions (Title and Organizational Affiliation)	Person(s) Responsible for Monitoring Effectiveness of Corrective Action (Title and Organizational Affiliation)	Timeframe for Corrective Action
Daily field documentation reviews	Field notes/email	Field team leader, CH2M	Brett Fishwild, site manager, CH2M Field team leader, CH2M	As soon as notification of corrective action is received
Data review and verification	Corrective action reports and/or updated case narratives and corrected data submissions	Jaime Sutton, project chemist, CH2M ALS Global Laboratory, QA officer	Jaime Sutton, project chemist, CH2M	3 to 5 business days

Worksheet #34—Data Verification and Validation Inputs

To ensure that scientifically sound data of known and documented quality are used in making environmental decisions, the following three-step data review will be performed. Step I (verification) will confirm that all specified activities involved in collecting and analyzing samples have been completed and documented, and that the necessary records (objective evidence) are available to proceed to data validation. Step II (validation) will assess whether the sampling and analytical processes comply with the contract-specific and the QAPP-specific requirements. Step III (usability assessment) will determine whether the resulting data are suitable as a basis for the decision being made. **Worksheets #34 to #37** describe the processes to be followed. **Worksheet #34** establishes the procedures that will be followed to verify project data, including, but not limited to, sampling documents and analytical data package. The items subject to verification and validation are listed in the following table.

Item	Description	Verification (completeness)	Validation (conformance to specifications)
Planning Documents/Records			
1	Approved QAPP	X	
2	Field SOPs	X	
3	Laboratory SOPs	X	
Field Records			
4	Field logbooks	X	X
5	Sample processing logs	X	X
6	Boring logs	X	X
7	HAPSITE logs and data	X	X
7	Chain-of-Custody Forms	X	X
8	Field corrective action reports	X	X
Analytical Data Package			
9	Cover sheet (laboratory identifying information)	X	X
10	Case narrative	X	X
11	Internal laboratory chain-of-custody	X	X
12	Sample receipt records	X	X
13	Sample chronology (that is, dates and times of receipt, preparation, and analysis)	X	X
14	RL/MDL establishment and verification	X	X
15	Standards traceability	X	X
16	Instrument calibration records	X	X
17	Definition of laboratory qualifiers	X	X

Item	Description	Verification (completeness)	Validation (conformance to specifications)
18	Results reporting forms	X	X
19	QC sample results	X	X
20	Corrective action reports	X	X
21	Electronic data deliverable	X	X

Worksheet #35—Data Verification Procedures

Verification Input	Description	Internal/ External	Responsible for Verification (Name, Organization)
Field Notes and Data	Verify that records are present and complete for each day of field activities. Verify boring logs. Verify that all planned samples including field QC samples were collected and that sample collection locations are documented. Verify that meteorological data were provided for each day of field activities. Verify that changes/exceptions are documented and were reported in accordance with requirements. Verify that HAPSITE logs are complete and accurate. Review the QC data to verify all exceptions have been identified and communicated to the project team.	Internal	TBD, field team leader, CH2M Brett Fishwild, site manager, CH2M
Chain-of-Custody and Shipping Forms	Verify the completeness of chain-of-custody records. Examine entries for consistency with the field logbook and sample processing log. Check that appropriate methods and sample preservation have been recorded. Verify that the required volume of sample has been collected and that sufficient sample volume is available for QC samples (for example, MS/MSD). Verify that all required signatures and dates are present. Check for transcription errors.	Internal/ External	TBD, field team leader, CH2M Jaime Sutton, project chemist, CH2M ALS Global Laboratory, QA Manager
Laboratory Data	Verify that the laboratory deliverable contains all records specified in the QAPP. Check sample receipt records to ensure sample condition upon receipt was noted, and any missing/broken sample containers were noted and reported according to plan. Compare the data package with the chains of custody to verify that results were provided for all collected samples. Review the narrative to ensure all QC exceptions are described. Check for evidence that any required notifications were provided to project personnel as specified in the QAPP. Verify that necessary signatures and dates are present.	Internal	Jaime Sutton, project chemist, CH2M

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Worksheet #36—Data Validation Procedures

Matrix	Analytical Group	Required Deliverable	Validation Percentage	Validation Criteria	Data Validator (title and organizational affiliation)
Soil Vapor and Air	TO-15 and TO-15 SIM	Level IV Data Report and EQuIS-compatible EDD	100% Level III	EPA National Functional Guidelines, laboratory SOPs, and QAPP criteria	Jaime Sutton, project chemist, CH2M

Data Verification/Validation Scope Overview

The CH2M project chemist will perform level III data validation on 100 percent of the TO-15 and TO-15 SIM analytical data for all soil vapor and air samples in accordance with EPA's National Functional Guidelines, the site-specific QAPP, and laboratory SOPs.

Field and HAPSITE Data Review

Field-generated information may include field logbooks, boring logs, sample chain-of-custody forms, shipping documents, sampling observations, sample labels, and other miscellaneous field observations. All field measurements and or field log information will be entered into field logbooks and reviewed daily by the field team leader or designee. The designee may be a qualified field geologist, engineer, environmental scientist, and/or technician.

All analytical data generated with the HAPSITE will be verified by a CH2M project chemist. The data review process will include checking all QC elements and making sure, when necessary, data are qualified appropriately. The instrument chromatograms and spectra may also be reviewed to verify that the VOCs are properly identified and the results are properly quantitated. An edata deliverable will be created for importing into the EqUIS database. In the event that a dilution is performed on a sample, one combined set of results will be reported from the analytical runs using the results or the reporting limit (if not detected) from the least dilute run possible without exceeding the calibration curve.

Laboratory Data Review Requirements

All analytical data generated by the laboratory will be verified before submittal to the CH2M project chemist. The internal data review process, which is multi-tiered, will include all aspects of data generation, reduction, and QC assessment. In each laboratory analytical section, the analyst performing the tests shall review 100 percent of the definitive data. After the analyst's review has been completed, 100 percent of the data will be reviewed independently by a senior analyst or by the supervisor of the respective analytical section using the same criteria.

Elements for review or verification at each level must include, but not be restricted to, the following:

- Sample receipt procedures and conditions
- Sample preparation
- Appropriate SOPs and analytical methodologies
- Accuracy and completeness of analytical results
- Correct interpretation of all raw data, including all manual integrations
- Appropriate application of QC samples and compliance with established control limits

- Documentation completeness (for example, all anomalies in the preparation and analysis have been identified, appropriate corrective actions have been taken and documented in the case narrative[s], associated data have been appropriately qualified, and anomaly forms are complete)
- Accuracy and completeness of data deliverables (electronic)

Laboratory Data Evaluation

The calibration, QC, corrective actions, and flagging requirements for definitive data are shown in **Worksheets #12, #15, #24, and #28**. The laboratory may apply data qualifiers based on its review or add a note in the laboratory case narrative. The definitions of any data qualifiers applied by the laboratory must be defined in the case narrative. The data qualifiers are reviewed by the supervisor of the respective analytical sections after the first and second level reviews of the laboratory data have been performed.

Data Review Guidelines

The laboratory assessment of the data quality will be reviewed for completeness and accuracy. Data review will be performed by a combination of electronic and manual methods and will include, but is not limited to, the following:

- Sampling documentation (such as the chain-of-custody form)
- Preservation summary and technical holding times
- Presence of all analyses and analytes requested
- Use of the required sample preparation and analysis procedures
- The method detection and reporting limits will be evaluated against the project requirements
- The correctness of the concentration units
- Case narrative

Data Verification/Validation Guidelines

The data verification process builds on data review. Project data will be reviewed and verified as part of the data assessment for this project. The review will be performed on an analytical batch basis by assessing QC samples and associated field sample results. Data verification guidelines have been developed in accordance with the method requirements, professional judgment, and general EPA National Functional Guidelines.

Summary data review and verification will be performed as follows:

- Chain-of-custody documentation
- Holding time
- QC sample frequencies
- Method and field blanks
- Laboratory control samples
- Surrogate spikes
- MS/MSD
- Initial and continuing calibration information
- Field duplicate precision
- Case narrative review and other method-specific criteria

The verification/validation process will be performed by a combination of electronic and/or manual methods and includes data flagging for issues related to method blanks, laboratory control samples, MS/MSD samples, field duplicates, surrogate recoveries, holding time, and reconciliation of dilutions and re-extractions. Data flags, as well as the reason for each flag, are entered into an electronic database and made available to the data users. A final flag is applied to the data by the CH2M project chemist after evaluating all flags entered into the database and selecting the most conservative of the verification flags.

If, during the data review and verification process, a systematic problem or other major issue with the data is identified, the CH2M project chemist will contact the laboratory's project manager or QA manager. Additional evaluation of the data may be performed including an in-depth review of the raw data to verify accuracy followed by analysis and interpretation of the data in the context of the project objectives and end-use as part of the usability assessment.

A data validation report will be prepared summarizing the findings and discussing their impact on the overall data usability. It will be incorporated into the final data evaluation summary report.

Flagging Conventions

CH2M-specific final data qualifier definitions are summarized in Table 36-1.

Table 36-1. Verification/Validation Data Qualifiers

Qualifier	Description
R	The data are unusable. The sample results are rejected due to serious deficiencies in meeting QC criteria. The analyte may or may not be present in the sample.
J	The result is an estimated quantity. The associated numerical value is the approximate concentration of the analyte in the sample.
UJ	The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the action limit of quantitation necessary to accurately and precisely measure the analyte in the sample.
U	The analyte was analyzed for, but was not detected above the reported sample quantitation limit.

Table 36-2 presents the general data validation guidelines with consideration to the EPA National Functional Guidelines to be used by CH2M for applying the data qualifiers.

Table 36-2. Data Qualifying Conventions—General

QC Requirement	Criteria	Flag	Flag Applied To
Holding Time	Time exceeded for extraction or analysis by a factor of 2 or more	J for positive results; R or UJ for nondetects*	All analytes in the sample
Sample Preservation	Sample not preserved (if sample preservation was not done in the field but was performed at the laboratory upon sample receipt, no flagging is required)	J for positive results; R or UJ for nondetects*	Sample
	Temperature out of control	J for positive results; UJ for nondetects*; R based on professional judgment	Sample
Sample Integrity (SW8260)	Bubbles in VOA vial greater than 4 millimeters (pea size) used for analysis	J for the positive results; UJ for nondetects; R based on professional judgment	Sample

Table 36-2. Data Qualifying Conventions—General

QC Requirement	Criteria	Flag	Flag Applied To
Instrument Tuning	Mass assignment error or Ion abundance method-specific criteria not met	R for all results, if critical ions involved, use judgment otherwise	All associated samples in analytical batch
Initial Calibration	All analytes must be within method specified criteria	J for positive results; UJ for nondetects; R based on professional judgment	All associated samples in analytical batch
Second Source Check or Continuing Calibration	All analytes must be within method specified criteria	High Bias: J for positive results, no flag for nondetects Low Bias: J for positive results, UJ for nondetects J positive/R all nondetects greater than twice the control criteria	All associated samples in analytical batch
Low-level Calibration Check or Interference Check Sample (SW6010 Only)	All analytes must be within 20% of expected value	High Bias: J positive results, no flag for nondetects Low Bias: J positive results, UJ nondetects J positive/R all nondetects greater than twice the control criteria	All associated samples in analytical batch
Internal Standards	Area greater than UCL Area less than LCL Sample is re-extracted and reanalyzed and recovery outside of criteria is confirmed as a matrix effect	J for positive results J for the positive results; UJ for the nondetects If area is too low based on professional judgment, UJ or R nondetects	Sample
Surrogates	%R greater than UCL %R less than LCL and greater than 10% %R less than 10% Excessive dilution	J for positive results J for positive results; UJ for nondetects J for positive results; R for nondetects No flag required	Sample
LCS	%R greater than UCL %R less than LCL and greater than 10% %R less than LCL and less than 10%	J for the positive results; J for the positive results; UJ for the nondetects J for the positive results; R for the nondetects	The specific analyte(s) in all samples in the associated analytical batch
Blanks (Method, Field, Equipment, Trip or Calibration)	Analyte(s) detected (use the blank of the highest concentration)	UB for positive sample results $\leq$ 5x highest blank concentration (10x for common laboratory contaminants)	All samples in preparation, field or analytical batch, whichever one applies
Field duplicates or Laboratory Duplicates	RPD > 30% for field duplicates, RPD > 20% for laboratory duplicates	J for positive results, no flag for nondetects	The specific analyte(s) in the associated sample Note: No flagging is required for results less than the reporting limit
Retention Time Window	Analyte outside of the established window	R for all results	Sample

Table 36-2. Data Qualifying Conventions—General

QC Requirement	Criteria	Flag	Flag Applied To
Canister Pressure (not applicable to Grab Samples) Initial vacuum should be 28 inches Hg (30 inches fully evacuated)	If Initial pressure 24 to 26 inches Hg If < 24 inches of Hg—Reject all data if used	J for positive results; UJ for nondetects R for all results	Sample Sample
	If final pressure >10 <20 inches Hg—sampling time may be extended if DQOs allow or the laboratory will dilute the sample	No Flag required	Sample
Final vacuum should be between 2 and 10 inches Hg (5 inches ideal)	If Final pressure > 20 inches Hg: Slight change (20 to 27 inches)	J for positive results; UJ for nondetects	Sample
	No change in pressure	Apply R to all data	Sample
Canister/Flow controller Certification (Individual)	Analyte(s) detected greater than RL	UB for positive sample results ≤ 5x blank concentration (10× for common laboratory contaminants)	Sample

Notes:

* Based on analyte-specific review

%R = percent recovery, LCL = lower confidence limit, LCS = laboratory control sample, duplicate, UCL = upper confidence limit

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Worksheet #37—Data Usability Assessment

The data usability assessment is an evaluation based on the results of data verification and validation in the context of the overall project decisions or objectives. The assessment determines whether project execution and resulting data meet the project DQOs. Both the sampling and analytical activities must be considered, with the ultimate goal of assessing whether the final, qualified results support the decisions to be made with the data.

The following subsections summarize the processes to determine whether the collected data are of the right type, quality, and quantity to support the environmental decision making for the project, and describes how data quality issues will be addressed and how limitations of the use of the data will be handled.

Summary of Usability Assessment Processes

It is the responsibility of the CH2M project chemist and the laboratory to ensure that the data meet the detection limits and laboratory QC limits listed in this QAPP. During the data verification assessment, nonconformances are documented and data are qualified for use in decision making. The data are determined to be usable by the project chemist based on the requirements of this QAPP. Data gaps will be present if a sample is not collected, a sample is not analyzed for the requested parameters, or the data are determined to be unusable. The need for further investigation will be determined on a case-by-case basis. All data are usable as qualified by the data validator, with the exception of rejected data. Estimated and/or biased results are usable. Outliers, if present, can be addressed on a case-by-case basis. There is no generic formula for determining whether a result is an outlier. Potential outliers will be referred to a statistician and senior consultant, who will determine which formulas are appropriate for classifying data points in a statistically appropriate and defendable manner.

Evaluation Procedures to Assess Project-specific Overall Measurement Error

In-depth assessment occurs during the data verification process. The verification will assess conformance with the requirements of the methods, SOPs, and objectives of this QAPP. The findings of the data verification process will generate qualifiers applied to the data considered in context to assess overall usability of the data.

Personnel Responsible for Performing Usability Assessment

- Jaime Sutton, project chemist, CH2M
- Rick Dobbins, database manager, CH2M
- David Boehnker, senior technical consultant, CH2M
- Chris Lutes, VI subject matter expert, CH2M
- Jennifer Simms, VI subject matter expert, CH2M
- Mike Bedan, subject matter expert/human health risk assessor, CH2M
- Ben Thompson, Lead HAPSITE Technologist, CH2M
- Jodi Sanchez, environmental manager, CH2M
- Brett Fishwild, site manager, CH2M
- Sally Scott, assistant site manager, CH2M

Usability Assessment Documentation

The data verification report will identify precision and accuracy exceedances with respect to the laboratory performance for each batch of samples, as well as comparability of field duplicates. All the results will be assembled and statistically reported for an overall quality assessment provided in the final data evaluation summary report. Discussion will cover precision, accuracy/bias, representativeness, comparability, and completeness defined as follows.

Precision

Laboratory precision is measured by the variability associated with duplicate (two) or replicate (more than two) analyses.

Total precision is the measurement of the variability associated with the entire sampling and analytical process. It is determined by analysis of duplicate field and/or laboratory samples and measures variability introduced by both the laboratory and field operations. Field duplicate samples will be analyzed to assess field and laboratory precision. For duplicate sample results, the precision is evaluated using the relative percent difference (RPD). For replicate results, the precision is measured using the relative standard deviation (RSD). The formula for the calculation of RPD is provided below.

If calculated from duplicate measurements:

$$RPD = \frac{(C_1 - C_2)\ x\ 100\ \%}{(C_1 + C_2)\ /\ 2} \quad (1)$$

Where:

RPD = relative percent difference
C_1 = larger of the two observed values
C_2 = smaller of the two observed values

If calculated from three or more replicates, use RSD rather than RPD:

$$RSD = (s / \bar{y})\ x\ 100\% \quad (2)$$

Where:

RSD = relative standard deviation
s = standard deviation
$\bar{y}$ = mean of replicate analyses

Standard deviation, s, is defined as follows:

$$S = \sqrt{\sum_{i=1}^{n} \frac{(yi - \bar{y})^2}{n - 1}} \quad (3)$$

Where:

S = standard deviation
yi = measured value of the i^{th} replicate
$\bar{y}$ = mean of replicate analyses

n	=	number of replicates

Accuracy

Accuracy reflects the total error associated with a measurement. A measurement is considered accurate when the reported value agrees with the true value or known concentration of the spike or standard within acceptable limits. Analytical accuracy is measured by comparing the percent recovery of analytes spiked into an LCS to a control limit. Surrogate compound recoveries are also used to assess accuracy and method performance for each sample analyzed.

Both accuracy and precision are calculated for each analytical batch, and the associated sample results are interpreted by considering these specific measurements.

The formula for calculation of accuracy is included below as percent recovery (%R).

$$\%R = 100\%\ x \left[\frac{S - U}{C_{sa}} \right] \tag{4}$$

Where:

$\%R$	=	percent recovery
S	=	measured concentration in spiked aliquot
U	=	measured concentration in unspiked aliquot
C_{sa}	=	actual concentration of spike added

For situations where a standard reference material is used instead of or in addition to MSs:

$$\%R = 100\%\ x \left[\frac{C_m}{C_{sm}} \right] \tag{5}$$

Where:

$\%R$	=	percent recovery
C_m	=	measured concentration of standard reference material
C_{sm}	=	actual concentration of standard reference material

Representativeness

Representativeness is the degree to which sample data accurately reflect the characteristics of a population of samples. It is achieved through a well-designed sampling program and by using standardized sampling strategies and techniques and analytical procedures. Factors that can affect representativeness include sample collection, storage, preservation procedures, site homogeneity, sample homogeneity at a single point, and available information around which the sampling program is designed.

Completeness (Statistical)

Completeness is a measure of the amount of valid data obtained compared with the amount expected under correct, normal conditions. It is calculated for the aggregation of data for each analyte measured as a compound of concern for the project objectives. Valid data are data that are usable in the context of the project goals. Completeness is calculated and reported for each method, matrix, and analyte combination. The number of valid results divided by the number of possible individual analyte results, expressed as a percentage, determines the completeness of the data set. For completeness requirements, valid results are all results not qualified with an R-flag after a usability assessment has been performed. The goal for completeness, based on specific project goals, is 90 percent.

Defined as follows for all measurements:

$$\%C = 100\% \ x \left[\frac{V}{T} \right] \tag{6}$$

Where:

%C	=	percent completeness
V	=	number of measurements judged valid
T	=	total number of measurements

Comparability

Comparability is the confidence with which one data set can be compared to another. It is achieved by maintaining standard techniques and procedures for collecting and analyzing samples and reporting the analytical results in standard units.

For this project, comparability will also be assessed through evaluation of the short duration Summa canister samples against the HAPSITE results. Those samples pairs will have an objective of a relative percent difference of less than 50 in the intermethod comparison when the concentration of a given analyte in a given sample is within the quantification range of the instrument/laboratory.

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Figures

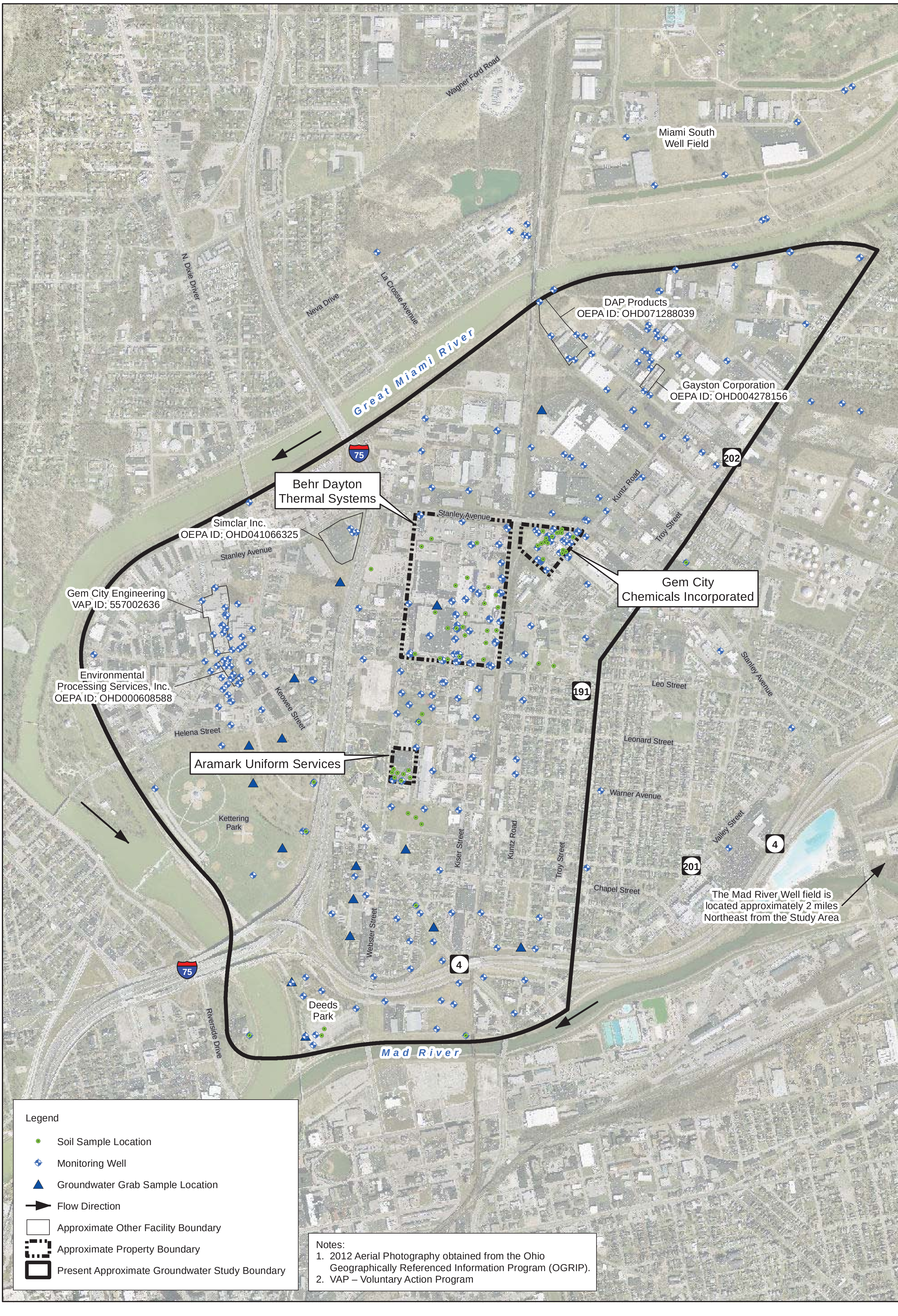

Figure 1
Site Plan
Behr Dayton Thermal System VOC Plume Site
Dayton, Ohio

\\MKEFPP01\PROJ\USENVIRONMENTALPROTE\420125_BEHRDAYTONTHERMAL\MAPFILES\2016\RI_REPORTMAY2016\UPDATES_20160801\FIGURE 1-2 - SITE PLAN.MXD ET024983 8/12/2016 12:20:09 PM

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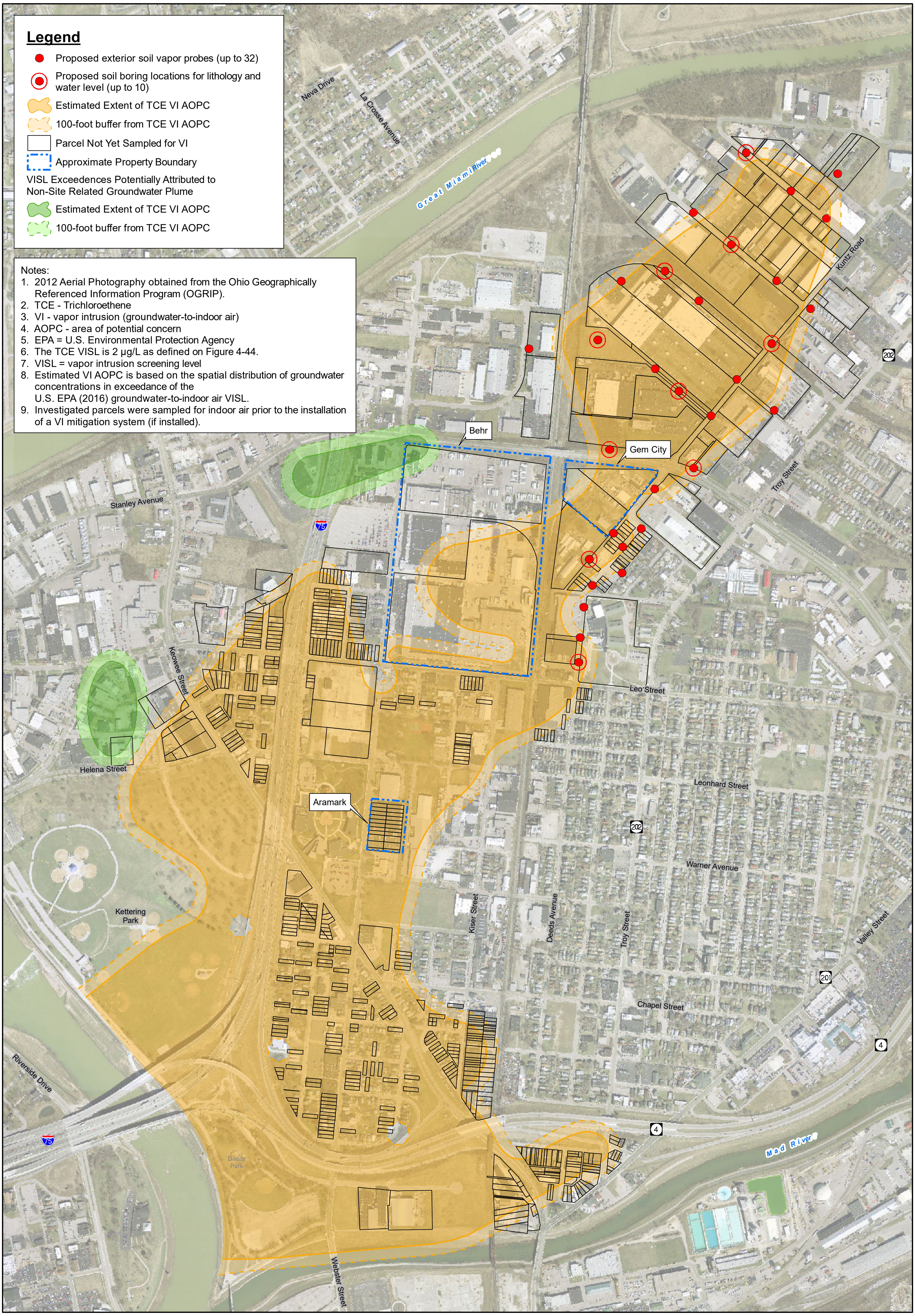

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Feet

Figure 2
Parcels Not Yet Sampled for VI and Proposed Exterior Soil Vapor Probe Locations
Behr Dayton Thermal System VOC Plume Site
Dayton, Ohio

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\\MKEFPP01\PROJ\USENVIRONMENTALPROTE\420125_BEHRDAYTONTHERMAL\MAPFILES\2017\QAPP\FIGURE 2 - PARCELS NOT YET SAMPLED FOR VI AND PROPOSED EXT SVP LOCS.MXD JHANSEN1 9/26/2017 4:22:54 PM

Appendix A
Field Standard Operating Procedures

Field Operating Procedure Utility Clearance for Intrusive Operations

Prepared by: Jennifer Simms **07/07/2017**

Jen Simms

Author

Reviewed by: Brett Fishwild **date**

Site Manager

Approved by: Kimberly Amley **07/07/2017**

Kimberly Amley

Project Quality Manager

Utility Clearance for Intrusive Operations

Purpose

This Field Operating Procedure (FOP) describes the utility mark-out and clearance process to be followed before completing any exterior or interior intrusive subsurface activities.

Scope

This FOP describes the utility mark-out and clearance process to be followed before any exterior or interior intrusive activities. The FOP discusses steps that must occur before mobilizing and during intrusive work.

Equipment and Materials

The private utility locator will supply the necessary equipment and materials.

Procedures and Guidelines

Before Mobilizing to the Field

Before mobilizing to perform exterior intrusive work, the state One Call Center must be called and utility companies must mark out the utility lines. The decision of get a public utility clearance for intrusive work inside of buildings should be made on a project- and site-specific basis. The public utility clearance will only be performed to the private property boundary.

Public Utilities

The state One Call Center **must** be contacted before any exterior intrusive work. The following general information must be provided during the call:

- Your name, company, address, and phone number where you can be reached, and the company doing the digging.
- The name and phone number of the site contact.
- The county and city or county and unincorporated area of the township of the excavation.
- The location of the intrusive work, which may include, but not be limited to, address, cross street, and lot numbers. At least one of the following must be provided: (1) appropriate section and quarter section grid information; (2) sufficient address or descriptive information to allow the establishment or drawing of a dig site polygon; (3) sufficient address, street, and cross-street information to allow for the determination of the appropriate section and quarter section grid(s); or (4) global positioning system coordinates.
- The start date and time of the planned activities.
- If subcontractors are responsible for utility locates, proper documentation must be received from them before the start of intrusive activities and placed in the project folder.

While on the phone with the One Call Center, the following information should be collected and documented in the project files:

1. **Members Notified.** The identity of One Call members notified will be provided to the caller. Retain a copy in the project files and keep it onsite while intrusive work is being performed.
2. **Case Reference Number.** An identification number associated with the call should be retained for future reference, if needed. Retain a copy in the project files and keep it onsite while intrusive work is being performed.

The site safety coordinator should retain a copy in the project records and keep it onsite while intrusive work is being performed.

All public utilities in the area where intrusive work is to be performed should be marked out on the ground by the utility locator using the American Public Works Association (APWA) Uniform Color Code (Attachment 1).

Utility locates are good for 21 calendar days, including the day the call was made. Extended tickets are available and will be extended, and the state One Call Center must be notified if extended tickets are needed.

Private Utility Clearance – Exterior Intrusive Work

Utilities must be cleared by a private utility locator before any exterior intrusive work as follows:

1. Identify the location(s) where intrusive work will occur during a site visit with the private utility locator. The proposed areas where intrusive work will be performed should be premarked before this site visit. It is important to take access issues into consideration while premarking.
2. Verify that the public utility clearance has been completed before beginning the private utility clearance. If it has not been cleared, the state One Call Center must be notified to complete the public utility clearance before the private utility clearance may be performed.
3. Oversee the following tasks performed by the private utility subcontractor:
    - 3.1. Clear a 10-foot by 10-foot area around the area where intrusive work will be performed. Additional area (if possible) to be cleared by the private utility locator is based on the work to be performed.
    - 3.2. Use surface geophysical methods (for example, direct-connect wire tracing, metal detecting, ground penetrating radar, magnetometers, air knife, Acoustic Pipe Locator, RD-7000 locator and Transmitter, Cable Avoidance Tool, and Genny), to identify underground utility lines, pipes, structures, or anomalies.
    - 3.3. Identify, mark out, and differentiate between any underground utilities (for example, electrical, water, gas, sewer, telephone, and cable lines), buried pipes, process lines, structures, and anomalies within the subsurface.
    - 3.4. The cleared area should be marked with white paint or flags, and the proposed intrusive work location should be identified with white paint or flags. Mark with color-coded spray paint and/or pin flags using the same standard color schemes as the state One Call Center shown in Attachment 1 (to indicate electric, gas, water, steam, telephone, TV cable, fiber optic, sewer, and foundation), all identified underground utility lines, structures, and anomalies.
4. Record the name and telephone number of the representative conducting the utility clearances.
5. The utility clearance is applicable for a 30-day period. Any intrusive work conducted after this 30-day period requires a new utility clearance.

Private Utility Clearance – Interior Intrusive Work

Utilities must be cleared by a private utility locator before any interior intrusive work as follows:

1. Identify the location(s) where intrusive work will occur during a site visit with the private utility locator. It is important to take access issues into consideration when the areas to be cleared are designated.
2. Oversee the following tasks performed by the private utility subcontractor:
   - 2.1. Clear a 2-foot by 2-foot area around the area where intrusive work will be performed. Additional area (if possible) to be cleared by the private utility locator is based on the work to be performed.
   - 2.2. Use ground-penetrating radar, electronic utility-locating equipment, and other utility locator technologies that are necessary to identify and differentiate between underground utilities, pipes, structures, or anomalies. A concrete scanner, which is a type of ground-penetrating radar designed for use on concrete slabs, should be used for utility clearance inside of a building.
   - 2.3. Identify, mark out, and differentiate between any underground utilities (for example, electrical, water, gas, sewer, telephone, and cable lines), buried pipes, process lines, structures, anomalies, conduit, rebar, post-tension cables, radiant floor tubing, wire mesh, and other nonconductive targets within or below the concrete slab.
   - 2.4. The cleared area and the proposed drilling location should be marked with chalk, crayons, or tape. If it is not possible to mark utilities, provide a figure that shows the field team exactly where the utilities are located and the extent of the area marked.
3. Record the name and telephone number of the representative conducting the utility clearances.
4. The utility clearance is applicable for a 30-day period. Intrusive work conducted after this 30-day period requires a new utility clearance.

Before and During Intrusive Work

The following should be completed before commencing intrusive work:

1. For exterior intrusive work, verify that all public utility companies have identified the presence of utilities with marking paint or have provided a response back indicating the absence of utilities in the area. To verify what the utility markings on the ground indicate, use the color code in Attachment 1 (for public utilities). If utilities have not been marked or a negative response has not been confirmed, do not perform intrusive work in that area. Contact the state One Call Center and alert them of the situation.

5. For exterior intrusive work being performed by a subcontractor with a drilling rig, review the utility clearance documentation with the drilling subcontractor during the tailgate meeting.

6. For exterior intrusive work, use other methods to identify utilities if there are numerous utility lines around the area and/or lines that cannot be clearly located where intrusive work is to be performed. If possible, hand-digging or hand-augering will be performed down to 5 feet below ground surface (bgs). Another method would involve the use of an air knife to bore 5 feet bgs with the use of high-pressure air that would not damage any utilities encountered.

7. Intrusive work can only be performed in the cleared area. If intrusive work needs to be performed outside of the cleared area, the appropriate utility locator(s) must clear the new location. If the new

area cleared involves private utilities, an addendum to the initial utility clearance signoff sheet should be provided.

8. While performing intrusive work, monitor for signs of an encounter with a utility line. These signs include encountering fill material such as gravel, sand, or other fill material; warning tape; plastic; or metal. If it is believed that a utility was struck, stop work, call the appropriate personnel, and document in the field logbook.
9. If refusal occurs while drilling and it is believed not to be related to a utility, then advancement will be tried up to two more times within the cleared area. If the same refusal is observed, then the location will be abandoned.

Quality Control and Quality Assurance

The field notes and utility-locate drawings will be reviewed by the field quality manager at the end of each work day performed.

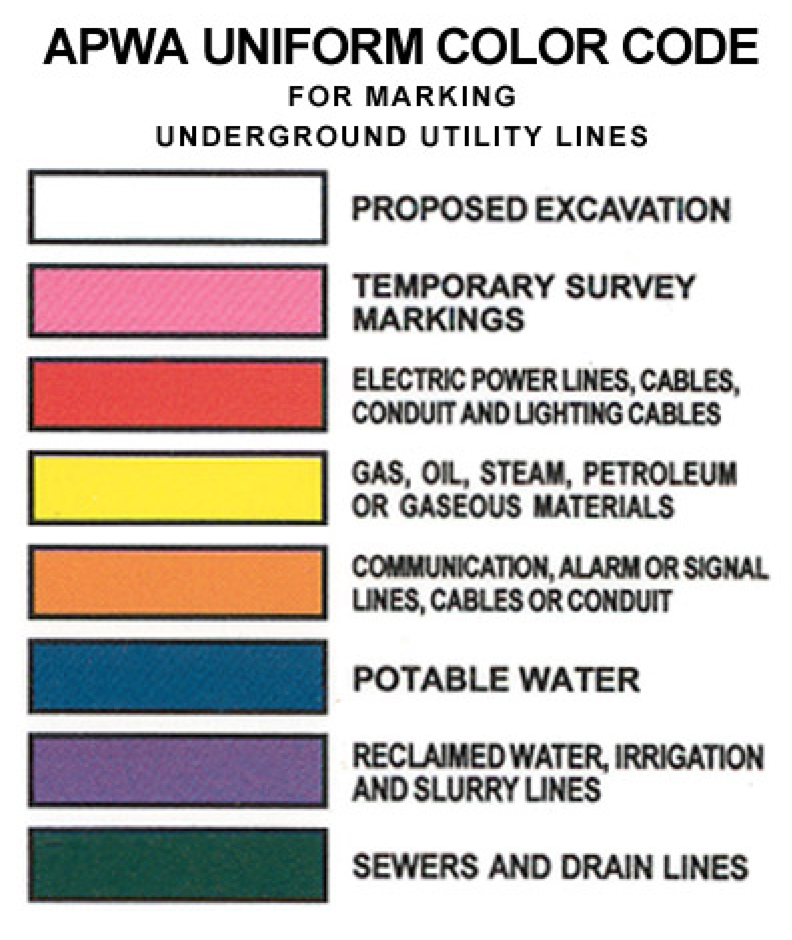
Attachments

APWA Uniform Color Code

References

Not applicable.

Attachment 1



Field Operating Procedure
Soil Boring Logging

Prepared by: Jennifer Simms **07/07/2017**

Jen Simms

Author

Reviewed by: Brett Fishwild **date**

Site Manager

Approved by: Kimberly Amley **date**

Kimberly Amley

Project Quality Manager

Soil Boring Logging

Purpose

This field operating procedure (FOP) provides guidance to obtain accurate and consistent descriptions of soil characteristics during soil logging.

Scope

The characterization is based on visual examination and manual tests, not on laboratory determinations. The logging of soil borings will be conducted in general accordance with ASTM International (ASTM) Designation D 2488-93: Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).

Equipment and Materials

- Soil boring log forms
- Soil logging guide
- Clean plastic sheeting
- Clean Department of Transportation-approved 55-gallon steel drum and label
- Tape measure
- Pocket penetrometer (optional)
- Photoionization detector (PID)
- Clean latex or nitrile gloves
- 12-inch ruler
- Hand lens
- Color Chart for Soil and Rock

Procedures and Guidelines

This FOP describes the general guidelines for soil characterization including instructions for completing the CH2M HILL, Inc. (CH2M) soil boring log, field classification of soil, and standard penetration test procedures.

Instructions for Completing Soil Boring Logs

Soil boring logs will be completed on the CH2M soil boring log. The information collected in the field to perform the soil characterization is described herein. Field personnel should review completed logs for accuracy, clarity, and thoroughness of detail. Analytical samples also should be checked to see that information is correctly recorded on both jar lids and labels and on the log sheets. Print all information on the field log form—do not write in cursive.

Heading Information

Boring Number. Enter the boring number. A numbering system should be chosen that does not conflict with information recorded for previous exploratory work done at the site. Number the sheets consecutively for each location.

Location. If station, coordinates, mileposts, or similar project layout information is available, indicate the position of the boring to that system using modifiers such as "approximate" or "estimated" as appropriate.

Elevation. Elevation will be determined at the conclusion of field activities.

Contractor. Enter name of the company and the city and state where it is based.

Drilling/Excavation Method and Equipment. Identify the bit size and type and method of drilling (for example, rotary and hollow-stem auger); and note information on the drilling equipment (for example, CME 55 and Mobile B61). For excavations, enter type of equipment used (such as, make and model of equipment).

Water Level and Date. Enter the depth below ground surface to the apparent water level in the borehole and excavation. Note if free water is not encountered during drilling and excavation or cannot be detected because of the drilling method. Record date and time of day of each water level measurement.

Date of Start and Finish. Enter the date(s) and time(s) the boring and excavation was begun and completed.

Logger. Enter the first initial and full last name of the person completing the form and describe the materials from the borehole.

Technical Data

Depth Below Ground Surface. Use a depth scale that is appropriate for the sample spacing and for the complexity of subsurface conditions.

Sample Interval. Note the depth at the top and bottom of the sample interval.

For Soil Borings:

- **Sample Type and Number.** Enter the sample type and number; for example, DP 1 = split spoon, first sample. Number samples consecutively regardless of type. Enter a sample number even if no material was recovered in the sampler.
- **Sample Recovery.** Enter the length to the nearest 0.1 foot of soil sample recovered from the sampler. Often, there will be some wash or caved material above the sample; do not include the wash material (such as slough) in the measurement. Record recovery in feet.

Soil Description. The soil classification should follow the format described in the "Field Classification of Soil" subsection herein.

Comments. Include all pertinent observations (for example, rod drops, rod bounce as in driving on a cobble, and equipment malfunctions). In addition, note if casing was used, the sizes, and depths installed. Instruct the driller to alert you of any significant changes in drilling (changes in material, occurrence of boulders). Such information should be attributed to the driller and recorded in this column.

Field Classification of Soil

This section presents the format for the field classification of soil. In general, the approach and format for classifying soils should conform to ASTM D 2488, Visual-Manual Procedure for Description and Identification of Soils.

The Unified Soil Classification System is based on numerical values of certain soil properties that are measured by laboratory tests. It is possible, however, to estimate these values in the field with reasonable accuracy using visual-manual procedures (ASTM D 2488). In addition, some elements of a complete soil description, such as the presence of cobbles or boulders, changes in strata, and the relative proportions of soil types in a bedded deposit, can be obtained only in the field.

Soil descriptions should be precise and comprehensive without being verbose. The correct overall impression of the soil should not be distorted by excessive emphasis on insignificant details. In general, similarities rather than differences between consecutive samples should be stressed.

Soil descriptions must be recorded for every soil sample collected. The format and order for soil descriptions should be as follows:

- Soil name (synonymous with ASTM D 2488 Group Name) with appropriate modifiers. Soil name should be in all capitals in the log; for example, "Sandy CLAY"
- Group symbol, in parentheses; for example, "(CL)"
- Color, using Munsell color designation if appropriate
- Moisture content
- Relative density or consistency
- Soil structure, mineralogy, or other descriptors

This order generally follows the format described in ASTM D 2488.

Soil Name

The basic name of a soil should be the ASTM D 2488 Group Name, based on visual estimates of gradation and plasticity. The soil name should be capitalized.

Examples of acceptable soil names are illustrated by the following descriptions:

- A soil sample is visually estimated to contain 15 percent gravel, 55 percent sand, and 30 percent fines (passing No. 200 sieve). The fines are estimated as either low or high plastic silt. This visual classification is Silty SAND with gravel, with a Group Symbol of (SM).
- Another soil sample has the following visual estimate: 10 percent gravel, 30 percent sand, and 60 percent fines (passing the No. 200 sieve). The fines are estimated as low plastic silt. This visual classification is Sandy SILT. The gravel portion is not included in the soil name because the gravel portion was estimated as less than 15 percent. The Group Symbol is (ML). However, the description of this sample should include the term…"with some gravel" after the descriptive terminology of the primary soil group.

The gradation of coarse-grained soil (more than 50 percent retained on No. 200 sieve) is included in the specific soil name in accordance with ASTM D 2488. There is no need to further document the gradation. However, the maximum size and angularity or roundness of gravel and sand-sized particles should be recorded. For fine-grained soil (50 percent or more passing the No. 200 sieve), the name is modified by the appropriate plasticity/elasticity term in accordance with ASTM D 2488.

Interlayered soil should each be described starting with the predominant type. An introductory name, such as "Interlayered Sand and Silt," should be used. In addition, the relative proportion of each soil type should be indicated.

Where helpful, the evaluation of plasticity and elasticity can be justified by describing results from any of the visual-manual procedures for identifying fine-grained soils, such as reaction to shaking, toughness of a soil thread, or dry strength as described in ASTM D 2488.

Group Symbol

The appropriate group symbol from ASTM D 2488 must be given after each soil name. The group symbol should be placed in parentheses to indicate that the classification has been estimated.

In accordance with ASTM D 2488, dual symbols (for example, GP-GM or SW-SC) can be used to indicate that a soil is estimated to have about 10 percent fines. Borderline symbols (such as GM/SM or SW/SP) can be used to indicate that a soil sample has been identified as having properties that do not distinctly place the soil into a specific group.

Generally, the group name assigned to a soil with a borderline symbol should be the group name for the first symbol. The use of a borderline symbol should not be used indiscriminately. Every effort should be made to first place the soil into a single group.

Color

The color of a soil must be given. The color description should be based on the Munsell system. The color name and the hue, value, and chroma should be given.

Moisture Content

The relative degree of moisture present in a soil sample should be defined as dry, moist, or wet.

Relative Density or Consistency

Relative density of a coarse-grained (cohesionless) soil is based on N-values (ASTM D 1586). If an auto-hammer is not used to collect samples, this item should be left out of the description and explained in the Comments column of the soil boring log.

Consistency of fine-grained (cohesive) soil is properly determined using a pocket penetrometer. For purposes of environmental sampling, the 'rule of thumb' can be used. For example, very soft means the soil can be easily penetrated several inches by fist, soft is easily penetrated several inches by thumb, firm can be penetrated several inches by thumb with moderate effort, stiff is readily indented by thumb, but penetrated only with great effort, very stiff is readily indented by thumbnail, and hard is indented with difficulty by thumbnail.

Soil Structure, Mineralogy, and Other Descriptors

Discontinuities and inclusions are important and should be described. Such features include joints or fissures, slickensides, bedding or laminations, veins, root holes, and wood debris.

Significant mineralogical information such as cementation, abundant mica, or unusual mineralogy should be described. Human-made debris encountered in drilling, such as slag from mineral smelting activities, should be identified as such on the log, and otherwise described similar to soils, considering grain size, angularity, and moisture content.

Other descriptors may include particle size range or percentages, particle angularity or shape, maximum particle size, hardness of large particles, plasticity of fines, dry strength, dilatancy, toughness, reaction to Hydrochloride, and staining, as well as other information such as organic debris, odor, or presence of free product.

Quality Control and Quality Assurance

- The field quality manager will review the field notes by at the end of each work day performed.
- Check entries to the soil boring log and field logbook in the field for accuracy

- Check that drilling and sampling equipment is decontaminated prior to use at each location using the procedures defined in the FOP, Equipment Decontamination Procedures.

Attachments

- Soil Boring Log

References

U.S. Environmental Protection Agency. Office of Solid Waste and Emergency Response. 2015. *Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air*. June.

Cox Colvin. 2016. *Standard Operating Procedure – Installation and Extraction of the Vapor Pin*. September.

PROJECT NUMBER	BORING NUMBER
	SHEET 1 OF 2

SOIL BORING LOG

PROJECT : LOCATION :
ELEVATION : DRILLING CONTRACTOR :
DRILLING METHOD AND EQUIPMENT USED :
WATER LEVELS : START : END : LOGGER :

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (FT)	#/TYPE	PID READING (ppm)	CORE DESCRIPTION SOIL TYPE, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.	COMMENTS DEPTH OF SURFACE CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND START/STOP TIMES OF DAILY DRILLING RUNS.
5						
10						
15						
20						
25						
30						
35						
40						
45						

PROJECT NUMBER	BORING NUMBER
	SHEET 2 OF 2

SOIL BORING LOG

PROJECT : LOCATION :
ELEVATION : DRILLING CONTRACTOR :
DRILLING METHOD AND EQUIPMENT USED :
WATER LEVELS : START : END : LOGGER :

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (FT)	#/TYPE	PID READING (ppm)	CORE DESCRIPTION SOIL TYPE, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.	COMMENTS DEPTH OF SURFACE CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND START/STOP TIMES OF DAILY DRILLING RUNS.
50						
55						
60						
65						
70						
75						
80						
85						
90						

Installation and Abandonment of Temporary Exterior Soil Vapor Probes

Purpose

This Field Operating Procedure (FOP) presents general guidelines for installing and abandoning temporary exterior soil vapor probes with the Geoprobe post-run tubing (PRT) method. The number, location, analytical method (including sampling container), and sampling duration of soil vapor samples should be determined on a project-specific basis.

Scope

This is a general description of how to install temporary exterior soil vapor probes using the Geoprobe PRT method, and how to abandon them when sampling is complete.

Equipment and Materials

Geoprobe PRT method includes the following equipment, typically supplied by the drilling subcontractor:

- Direct-push drill rig
- Drive rods—possibly 1-inch, 1.25-inch, or 1.5-inch outer-diameter drive rods
- Expendable drive points—steel or aluminum 1.1-inch-outer-diameter expendable drive points
- PRT expendable point holder
- PRT adapters
- Post-run point popper
- Probe tubing—1/4-inch-outer-diameter Teflon tubing (may be supplied by the drilling subcontractor)
- Probe cap (to seal the tubing during equilibration)—Swagelok part number SS-400-C
- MultiRae five gas meter for health and safety monitoring during drilling. A MiniRae photoionization detector (PID) and Landtec GEM Landfill Gas Meter (or equivalent) may be used instead of the five gas meter.
- Electrical tape

Procedures and Guidelines

This FOP describes the general guidelines for installing and abandoning temporary exterior soil vapor probes with the Geoprobe post-run tubing method.

General Guidelines:

- As with all intrusive site work, a utility clearance should be performed before mobilization. It may also be necessary to acquire permits and site access.
- Although it is possible to install soil vapor probes while it is raining, care should be taken to ensure that water does not enter the borehole. Additionally, soil vapor sampling should not be performed until 48 hours after a significant rain event (defined as greater than 1 inch of rainfall).

- Before attempting installation of soil vapor probes, there should be an understanding of subsurface conditions at the site because with the Geoprobe PRT method the probe is pushed into the ground without creating a hole beforehand.
  – The soil vapor sampling interval should be installed above the capillary fringe and at least 5 feet below ground surface (bgs) to avoid short circuiting with outdoor air. If there is impermeable ground cover (e.g., concrete, asphalt), shallower sampling depths may be considered.
  – It may not be feasible to collect soil vapor from finer-grained or tight soils with little pore volume, such as clays
- Operation of direct-push machinery will be performed only by trained and licensed personnel.

Procedures for Installing Temporary Exterior Soil Vapor Probes using the Geoprobe PRT method:

1. Assemble the rods with the PRT point holder and expendable point (Figure 1). It is optional to have an O-ring on the expendable point. If an O-ring is used, then the post-run point-popper will be necessary to disengage the expendable point. If an O-ring is not used, the expendable point may fall off if a void space is encountered, or soils may clog the PRT point holder.
2. Push the probe to the desired depth with a direct-push rig. Ensure that the final depth of the drive point includes extra depth to include the length of the tip and the sampling interval when retracted (for example, for a depth of 5 feet below ground surface (bgs) with a 6-inch screen, push the probe to 5 feet 6 inches bgs).
3. Retract the probe to create an annular space. The retraction length is equal to the selected sampling interval length. It is advisable to check that the expendable point detached during retraction by poking the post-run point popper down the inside of the rod.
4. Attach the PRT adapter to the 1/4-inch OD Teflon tubing and secure in place by wrapping the connection with a small piece of electrical tape. This prevents the tubing from slipping on the nipple while tightening. Check that the o-ring on the PRT adapter is new and undamaged.
5. Feed the PRT adapter and tubing down the rod. When it reaches the point holder, cut the tubing so that an additional 2 to 3 feet of tubing remains above ground.
6. While pushing down on the tubing, twist in a counter-clockwise direction until the probe adapter and tubing seat. Test the connection by lightly tugging on the tubing.
7. Place the probe cap on the tubing.
8. Record the soil vapor probe installation information in the field logbook, including the sample interval depth, and installation completion time.
9. Wait 30 minutes after the probe is installed to begin purging, leak testing, and sampling, so that the subsurface has time to equilibrate.
10. The coordinates of each probe location should be documented using a hand-held global positioning system device.
11. The rods and reusable Geoprobe PRT parts (PRT point holder and adapter) must be decontaminated before use at each probe location. Steam cleaning is the preferred method of decontamination; however, a three-stage decontamination process consisting of a wash with a non-phosphate detergent, a rinse with tap water, and a final rinse with distilled water may be used. Once decontaminated, the equipment must be shown to be free of contaminants by screening them with a PID. If there are measurable total volatile organic compound concentrations above background levels, then the equipment should be decontaminated again concentrations are below background levels. New tubing must be used for each soil vapor probe; the tubing cannot be decontaminated.

Procedures for Abandoning Temporary Exterior Soil Vapor Probes using the Geoprobe PRT method:

1. Retract the rods with a direct-push rig.
2. Fill the borehole with either a bentonite slurry or with bentonite (granular or chipped) hydrated in lifts to the ground surface.

Replace ground surface covers and repair to original condition.

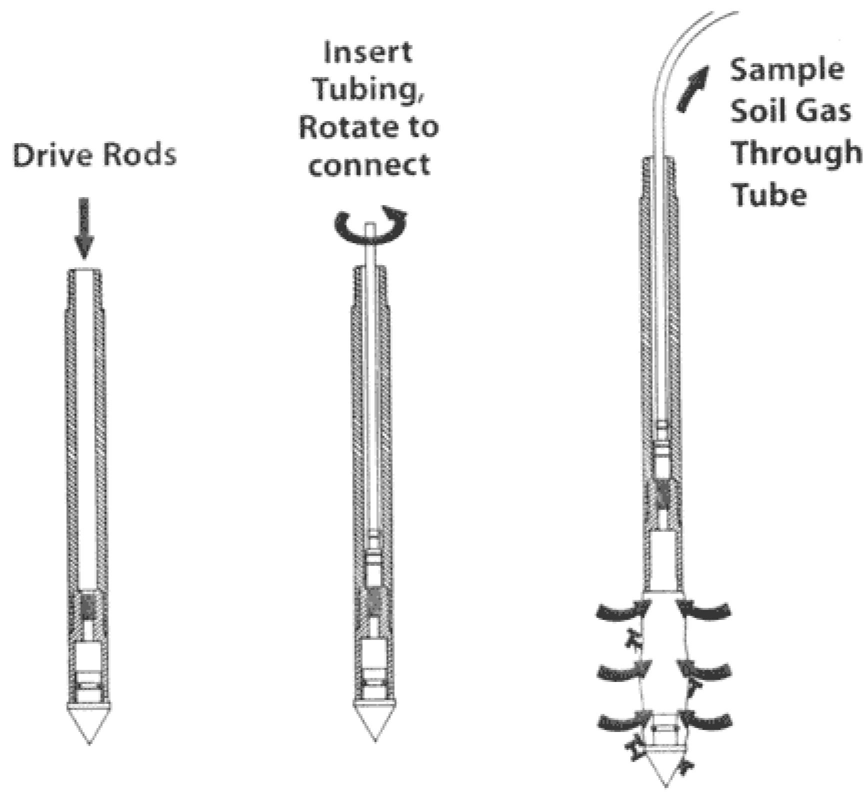


Figure 1. Geoprobe PRT System

Quality Control and Quality Assurance

The field notes should be reviewed by the field quality manager at the end of each work day performed.

References

Geoprobe Systems. 2013. *Soil Gas Sampling – PRT System Operation*. December 30.

Geoprobe Systems. 2006. *Direct Push Installation of Devices for Active Soil Gas Sampling & Monitoring. Technical Bulletin Number MK3098*. May.

Field Operating Procedure Installation and Abandonment of Temporary Exterior Soil Vapor Probes

Prepared by: Jennifer Simms **07/07/2017** Jen Simms

Author

Reviewed by: Brett Fishwild **date**

Site Manager

Approved by: Kimberly Amley **07/07/2017** Kimberly A Amley

Program Quality Manager

Soil Vapor Sampling Log

Project: ____________________

Sampler:

Sample Location Information

Property ID/Address: ____________________

Condition of ground in the surrounding area: ____________________

Location ID: ____________________ Sample ID: ____________________

Sample Location Description:

Soil Vapor Probe Leak Checking and Sampling Log

Manifold Leak Check

	Pass	*Fail*
Manifold leak check (procedure: ensure manifold holds pressure at -10 "Hg for 30 seconds). If using a pelican-case pump, open the lid during leak check to ensure all interior pieces are in-tact.		

Describe corrective measures taken to pass the manifold leak test: ____________________

Soil Vapor Probe Helium Leak Check and Purge Results

Purge rate (mL/Min): ____________________ Helium Conc. in the Purged Vapor: ____________________

Start Time: ____________________ Calculated leak percentage: ____________________

Purge Vacuum ("Hg): ____________________ Probe Leak Check Result*: *Pass* *Fail*

Avg. Helium Conc. in the Enclosure: ____________________

End Time: ____________________

*The soil vapor probe passes the leak test if the helium concentration in the purged soil vapor is less than 5% of what it was in the helium enclosure during purging. For example, if the helium concentration in the purged soil vapor is 2,300 ppm that is 0.23%, and the average helium concentration in the enclosure was 35%, then the percentage leak is 0.66% [0.23/35*100 = 0.66%]). Do NOT collect a soil vapor sample if the leak check fails.

Field Analysis (required readings are determined on a project-specific basis. Fill in all that are necessary):

MiniRAE or MultiRAE Photoionization Detector

Total VOCs (ppm): ____________ O_2 (%): ____________

H_2S (ppm): ____________ LEL (%): ____________

CO (ppm):

LandTec GEM Landfill Gas Meter

O2 (%): ____________

CO2 (%): ____________

CH4 (%):

Sampling Information

Evacuated Canister or Bottle-Vac

Container Size (L): ____________________ Initial Pressure (" Hg): ____________________

Container ID: ____________________ Start Date and Time: ____________________

Flow Controller ID: ____________________ End Date and Time: ____________________

Sampling Rate (mL/min, hours): ____________________ Final Pressure (" Hg): ____________________

Sampling Vacuum ("Hg):

Tedlar Bag

Tedlar Bag size (L): ____________________ Start Date and Time: ____________________

Sampling Rate (mL/min): End Date and Time:

Sorbent Tube

Sorbent Tube type and size: ____________________ Start Date and Time: ____________________

Sorbent Tube ID: ____________________ End Date and Time: ____________________

Initial Flow Rate (mL/min): ____________________ Final Flow Rate (mL/min) ____________________

Calculated Sampling Volume:

Weather Conditions and Additional Notes

Weather Conditions During Sampling: ____________________

____

____

Additional Notes: ____________________

____

____

Soil Vapor Sampling from Exterior Soil Vapor Probes

Purpose

This Field Operating Procedure (FOP) presents general guidelines for collecting soil vapor samples from temporarily-, semi-permanently-, or permanently-installed exterior soil vapor probes. The number, location, analytical method (including sampling container), and sampling duration of soil vapor samples should be determined on a project-specific basis.

Scope

This is a general description of how to purge and leak test exterior soil vapor probes and then collect soil vapor samples. This FOP describes sampling with evacuated canisters and additional optional sampling methods including Bottle-Vacs, gas sampling bags, and sorbent tubes.

Equipment and Materials

Purge and Helium Leak Test:

- Three-way sampling manifold consisting of Swagelok gas-tight fittings with three valves and one vacuum gauge to attach the probe to the vacuum pump and the sample canister.
- Vacuum pump (battery-powered) with rotometer to control flow to 200 milliliters per minute (mL/min).
- Teflon tubing, 0.25-inch outer diameter.
- Swagelok nut and ferrule set (part #SS-400-NFSET) for purge and sampling train connections.
- Gas sampling bag (such as Tedlar brand) (1-liter or 3-liter) to collect the purged soil vapor so the approximate volume of purged soil vapor can be measured and field screening can be performed on the purged vapor.
- Wrenches and screwdriver, various sizes as needed for connecting fittings. A 9/16-inch wrench fits the 0.25-inch Swagelok fittings.
- Helium enclosure to fit around the flush-mount probe cover for permanent soil vapor probes or over the drill rod for temporary probes.
- Helium - canister of high-purity helium with 0.5-liter per minute flow regulator.
- MGD Dielectric Helium Detector.
- Photoionization detector (PID; MiniRae or MultiRae) to monitor breathing zone volatile organic compound (VOC) concentrations. It is also optional to collect field measurements of total VOCs from the purged soil vapor; may warn the laboratory if high concentrations are detected so they can dilute the sample before analysis.
- LandTec GEM Landfill Gas Meter (optional) to collect field measurements of oxygen, carbon dioxide, and methane.

Soil vapor sampling with evacuated canisters:

- Stainless-steel sample canister(s) certified clean and evacuated (canisters are cleaned, evacuated, and provided by the laboratory.)
- Flow controller(s) set at desired sampling rate. (Flow controllers are cleaned, set, and provided by the laboratory.)
- Analog pressure gauge dedicated to the canister may be permanently attached to either the canister or flow controller. This pressure gauge will be used to monitor the canister pressure during sampling.
- Digital pressure gauge with a -30 to 0-inch mercury (Hg) range, and 0.50 inches Hg accuracy that should be verified annually. This pressure gauge should have a Swagelok 1/4-inch female connection because it will be used to measure the initial and final canister pressure. Digital gauges should not be shared between soil vapor samples and air samples (indoor, outdoor, or crawlspace) to prevent cross-contamination.
- Wrenches and screwdriver, various sizes as needed for connecting fittings. A 9/16-inch wrench fits the 0.25-inch Swagelok fittings, which most canisters and flow controllers have.
- Swagelok nut and ferrule set (part #SS-400-NFSET) to connect tubing to the sampling manifold.
- T-connector (provided by the laboratory) to collect simultaneous duplicate samples.
- Shipping container, suitable for protection of canister(s) during shipping. Typically, strong cardboard boxes are used for canister shipment. The canisters should be shipped to the laboratory in the same shipping container(s) in which they were received.

Alternative soil vapor sampling methods:

- Bottle-Vacs:
  - Bottle-Vac(s) (evacuated, and provided by the laboratory).
  - Flow controller set at desired sampling rate. (Flow controllers are cleaned, set, and provided by the laboratory.)
  - Digital pressure gauge with a -30 to 0-inch Hg range, and 0.50 inches Hg accuracy which should be verified annually. This pressure gauge should have a quick-connect connection because it will be used to measure the initial and final Bottle-Vac pressure. Digital gauges should not be shared between soil vapor samples and air samples (indoor, outdoor, or crawlspace) to prevent cross-contamination.
  - T-connector (provided by the laboratory) for collecting simultaneous duplicate samples.
  - Shipping container, suitable for protection of Bottle-Vac(s) during shipping. The Bottle-Vac(s) should be shipped to the laboratory in the same shipping container(s) in which they were received.
- Gas sampling bag (such as Tedlar brand):
  - Gas sampling bag
  - Lung box
- Sorbent Tubes:
  - Sorbent tube(s) (provided by the laboratory. Include one extra to use for flow calibration purposes.
  - SKC flow calibrator 5 to 500 mL/min to measure the exact flow rate while sampling.

Procedures and Guidelines

This FOP describes the general guidelines for purging and leak testing exterior soil vapor probes, then collecting soil vapor samples. Purging, leak testing, and sampling information should be recorded in the field logbook and on the attached "Soil Vapor Sampling Log" form.

General Guidelines

- Wait at least 48 hours after installation of permanent or semi-permanent soil vapor probes and at least 30 minutes after installation of temporary soil vapor probes with the Geoprobe post-run tubing system before purging, leak testing, and sampling the probes to allow the subsurface to equilibrate. Check local guidance and regulations to confirm these are appropriate equilibration times for the soil vapor probes.
- Soil vapor sampling should not be performed until 48 hours after a significant rain event (defined as greater than 1 inch of rainfall). Check local guidance and regulations to confirm these are appropriate waiting periods for sampling after precipitation.

System Setup:

1. Remove the protective cover (such as a flush-mount cover, or semi-permanent polyvinyl chloride [PVC] cover) on the soil vapor probe (if present).
2. Place the helium enclosure over the soil vapor probe and adjust it so that it will allow a buildup of helium in the enclosure. The enclosure should not be sealed tightly, and there should be an exhaust for the helium so pressure does not build up in the enclosure. Where the ground surface is soft, the helium leak-check enclosure can be pressed down slightly into the ground surface. Where the ground surface is hard (for example, asphalt), use a sealing material (foam tape or modeling clay) and apply a slight downward pressure to achieve a buildup of helium in the leak-check enclosure.
3. Remove the cap from the probe tubing and connect the probe tubing to the sampling manifold.
4. Attach the vacuum pump to the sampling manifold using Teflon tubing and Swagelok nut and ferrule sets.
5. System set up for canister sampling:
   5.1. Measure the initial canister pressure with the digital pressure gauge. The initial pressure should be between -28 to -30 inches Hg. If it is less than -26 inches Hg, do not use the canister for sampling. If it is between -28 to -26 inches Hg only use the canister if there are no other spare canisters available. In the field log, record the canister identification (ID), flow controller ID, initial vacuum, desired flow rate, sample location information, and all other information pertinent to the sampling effort.
   5.2. Connect the flow controller and analog pressure gauge to the canister. When the flow controller and pressure gauge are attached correctly they will not move separately from the canister (they will not spin around).
   5.3. Connect the canister via the flow controller to the sampling manifold.

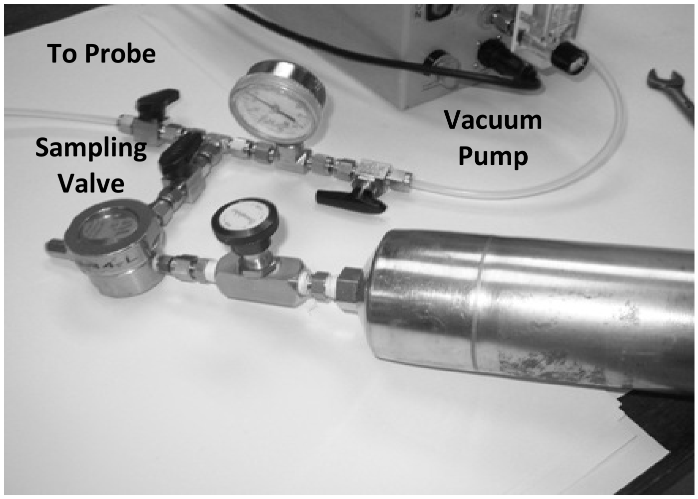


Figure 1. Sampling Manifold Setup for Canister Sampling

Manifold Vacuum Leak-Check:

The purpose of the manifold leak test is to make sure the connections in the sampling train are air tight. For canister sampling, the connections on the sampling manifold through the flow controller to the valve on the canister will be leak tested (Figure 1). For duplicate samples, the whole assembly with the T-connector should be vacuum leak tested. For alternative sampling methods, the connections on the sampling manifold will be leak tested.

1. Close the valve to the probe, open the valve to the pump. For canister sampling, open the sampling valve to the canister on the manifold; the valve on the canister is closed.
2. Turn the pump on and wait for the gauge on the manifold to reach approximately -10 inches Hg. Close the valve to the pump and turn the pump off. The sampling train is now a closed system.
3. Wait approximately 30 seconds to ensure that the vacuum is maintained and there are no leaks (as shown by the stability of the pressure gauge).
4. If there is a visible loss of vacuum, tighten the connections and redo the leak test until it passes.

System Purge and Helium Leak Check:

A purge of the soil vapor probe and sampling manifold system is required before taking each sample. The helium leak-check procedure is also performed during this step. This helium leak check will verify the integrity of the probe seal, sampling adapter (or post-run tubing [PRT] adapter if using the Geoprobe PRT system) seal, as well as the probe and ground interface; this is accomplished by completing the following steps:

1. Start the flow of helium under the leak-check enclosure. Let the helium fill the enclosure for a couple of minutes.
2. Turn the helium leak detector on while in outdoor air and ensure that the detector exposed to helium because it does a zero calibration every time it is turned on.
3. Verify that the helium concentration inside the leak-check enclosure is more than 10 percent by placing the probe of the helium detector into the enclosure.
4. Purging is carried out by pulling soil vapor through the system at a rate of 200 mL/min for a period sufficient to achieve a purge volume that equals 3 to 5 dead volumes (internal volume) of the in-ground annular space, sample line, and sampling manifold system.

4.1. When calculating the dead volume, be sure to consider the inside diameter and length of the Teflon sample tubing, as well as the probe outside diameter and retraction distance for the annular space of temporary probes.

4.2. For permanent probes, calculate the volume of the annular space using a nominal 30 percent porosity for the sand pack.

4.3. The gas sampling bag should be attached to the vacuum pump exhaust to collect the purged soil vapor so the approximate volume of purged soil vapor can be measured and field screening can be performed on the purged vapor.

5. Open the sample valve and the purge valve and start the vacuum pump. Verify that the flow rate is still 200 mL/min.

6. If there is shallow groundwater in the area, carefully watch the tubing as the pump is turned on. If water is observed in the sample tubing, shut the pump off immediately. Soil vapor collection will not be feasible if the probe is in contact with water.

7. Monitor the purging vacuum on the sampling manifold pressure gauge. The purging vacuum should not exceed -7 inches Hg; if it does, turn the pump off, close the valve to the pump, and wait to see if there is recovery. If there is no noticeable change in vacuum after several minutes, then there is an insufficient amount of soil vapor to collect a sample and the vacuum is too great to collect a soil vapor sample. Several factors can cause this situation, including the following (consult with the project manager and take corrective action):

7.1. The soil formation is too “tight” (that is, high clay or moisture content). Try using a lower flow rate (temporary or permanent probe). Try a different depth or location (temporary probe).

7.2. The probe screen, or annular space for temporary probes, may be in water even if the water has not yet come up in the tubing. Soil vapor sampling is not feasible if the probe is in contact with water. Try a different depth or location (temporary probe). Try sampling the probe again in dryer conditions (permanent probe).

7.3. With a temporary probe system (such as the Geoprobe PRT system), the expendable tip may not have released when the drive rod was retracted. Try retracting the probe a little further, or use the point run popper to poke the tip loose.

7.4. If purging cannot be completed without creating a vacuum exceeding -7 inches Hg, then the probe cannot be sampled.

8. Measure the helium concentration in the enclosure several times during purging to calculate an average concentration in the enclosure during the purge duration.

9. At the end of the calculated purge time and after the system is verified to be leak free, turn off the pump, close the valve to the pump, and close the valve to the probe. Close the valve on the gas sampling bag and remove the bag from the pump.

10. Measure the helium concentration in the purged soil vapor in the gas sampling bag. The helium concentration in the purged soil vapor must be less than 5 percent of what it was in the helium enclosure during purging to pass the leak test.

10.1. For example, if the helium concentration in the purged soil vapor is 2,300 parts per million (ppm), that is 0.23 percent, and the average helium concentration in the enclosure was 35 percent, then the percentage leak is 0.66 percent [0.23/35*100 = 0.66 percent]).

10.2. If the probe fails the leak check, then corrective action is required; this includes first checking the fittings and connections and trying another purge and leak check. It may also be necessary to remove the soil vapor probe, if it is temporary, and re-install it in a nearby location.

10.3. Helium leak detectors may be sensitive to high concentrations of methane or other atmospheric gasses. If high methane concentrations are expected to be present in the soil vapor, then caution should be used with this technique, as false positive readings may be encountered during leak testing. Use a Landtec GEM Landfill Gas Meter to determine if methane is present in the soil vapor.

11. Optional - Field readings of total VOCs with a PID, and/or oxygen, carbon dioxide, and methane with a LandTec GEM Landfill Gas meter may be performed on the purged soil vapor.
12. Record the purge and leak-check information on the Soil Vapor Sampling Log (attached).

Canister Sampling:

1. For extended duration samples (for example, 8- or 24-hour)
   1.1. Remove the sampling manifold by detaching the canister from the manifold, then detaching the probe tubing from the manifold and quickly attaching it to the canister via the flow controller.
   1.2. Attach the sign (identifying the canisters as an air sample, saying “Do Not Disturb” and providing contact information) to the canister.
   1.3. Make sure the canister will be secure at the sampling location; place traffic cones around the probe and canister if necessary.
2. To begin sampling, open the canister valve one full turn and record the sample start time. (For grab samples, the canister will still be attached to the sampling manifold.)
3. Monitor the canister pressure on the analog gauge (if present) several times during the sample period, to ensure the canister is filling at the desired rate and the final canister pressure does not fall to 0-inch Hg.
4. At the end of the sample period, close the canister valve and record the sample end time. Detach the canister from the manifold or probe tubing.
5. Measure the final canister pressure with the digital pressure gauge. The final pressure should be between -10 to -2 inches Hg. If it is 0-inch Hg, do not submit the sample for analysis. If it is between -2 and 0-inch Hg re-deploy the sample if possible; if not submit it to the laboratory for analysis but make sure it is received with some residual negative pressure.
6. Replace the protective cap on the canister.
7. Duplicate samples should be collected simultaneously with a dedicated T-connector.
   7.1. Grab sample duplicates should be collected by attaching the T-connector to each canister and then connecting one flow controller to the top of the T-connector. (If there was a flow controller on each canister, then the sampling flow rate would exceed the maximum allowable flow rate of 200 mL/min.) The duplicate sample will take twice as long to collect.
   7.2. Extended duration samples should be collected by attaching a flow controller to each canister and then connecting the T-connector to each flow controller. (If only one flow controller was used, then the sampling duration would be twice as long.)

Bottle-Vac Sampling:

1. Measure the initial pressure with the digital pressure gauge. The initial pressure should be between -28 to -30 inches Hg. If it is less than -26 inches Hg, do not use the Bottle-Vac for sampling. If it is between -28 to -26 inches Hg, only use the Bottle-Vac if there are no other spares available. In the field log record the Bottle-Vac ID, flow controller ID, initial vacuum, desired flow rate, sample location information, and all other information pertinent to the sampling effort.
2. For extended duration samples (for example, 8- or 24-hours):
   - 2.1. Remove the sampling manifold and attach the probe tubing to the flow controller.
   - 2.2. Attach the sign (identifying the canisters as an air sample, saying “Do Not Disturb” and providing contact information) to the canister.
   - 2.3. Make sure the canister will be secure at the sampling location; place traffic cones around the probe and canister if necessary.
3. For grab samples – Attach the flow controller to the sampling valve on the sampling manifold.
4. To begin sampling, attach the Bottle-Vac to the to the flow controller via the quick-connect and record the sample start time.
5. At the end of the sample period, detach the Bottle-Vac from the flow controller and record the sample end time. Detach the flow controller from the probe tubing or sampling manifold.
6. Measure the final Bottle-Vac pressure with the digital pressure gauge. The final pressure should be between -10 to -2 inches Hg. If it is 0-inch Hg, do not submit the sample for analysis. If it is between -2 and 0-inch Hg, re-deploy the sample if possible; if not submit it to the laboratory for analysis but make sure it is received with some residual negative pressure.
7. Duplicate samples should be collected simultaneously with a dedicated T-connector as described in the Canister Sampling section of this FOP.

Tedlar Bag Sampling:

1. Detach the vacuum pump from the sampling manifold and attach it to the lung box, then attach the probe tubing via the sampling manifold to the lung box influent.
2. Place a Tedlar bag in the lung box using dedicated Teflon and flexible silicon tubing.
3. To begin sampling, turn the pump on and record the sample start time.
4. Turn the pump off when the Tedlar bag is full and record the sample end time. The Tedlar bag should only be filled 50 percent if it will be shipped via plane.
5. Detach the probe tubing and vacuum pump from the lung box.

Sorbent Tube Sampling:

1. Disconnect the pump tubing from the manifold.
2. Attach a spare sorbent tube provided by the lab to the vacuum pump tubing using a 1/4-inch Swagelok union or flex tubing. Do not use a tube that is intended for sampling. Be sure to attach the sorbent tube so that the flow direction is correct.
3. Attach the SKC flow calibrator to the vacuum pump exhaust.
4. Turn on the vacuum pump and adjust the flow to achieve the desired flow rate of 200 mL/min using the flow calibrator.
5. Remove the spare sorbent tube from the pump tubing.

6. Remove the end caps from the sorbent tube to be used for sampling and attach it to the vacuum pump tubing using a 1/4-inch Swagelok union or flex tubing. Be sure to attach the sorbent tube so that the flow direction is correct. Record the sample tube ID on the field form.
7. Attach the other end of the sorbent tube to the sample manifold where the pump tubing used to be attached using either Swagelok fittings or flex tubing.
8. Make sure both the probe valve and the vacuum pump valve are open and the sampling valve is closed.
9. Start the pump and record the start time. Using flow calibrator, record initial flow rate.
10. If the flow rate starts to drop, it may indicate that the sorbent tube is becoming plugged with water. Stop the vacuum pump and record the end time.
11. After the required amount of time, record the final flow rate from the flow calibrator. Turn off the pump and remove the sorbent tube. Record the end time.
12. Replace the end caps on the sorbent tube. Replace the sorbent tube into the container it was received in.

After Sample Collection is Completed:

1. Disassemble the sampling system and replace the cap on the probe tubing.
2. For permanent probes - replace the protective cover (such as a flush-mount cover, or semi-permanent PVC cover) on the soil vapor probe (if present).
3. Fill out all appropriate documentation (chain of custody, sample tags) and return samples and equipment to the laboratory in the same shipping container in which they were received. Do not place sticky labels or tape on surface of the canister.
4. Canisters, Bottle-Vacs, and Tedlar bags should not be cooled during shipment. DO NOT put ice in the shipping container. Sorbent tubes may require ice for shipping.

Quality Control and Quality Assurance

- Canisters supplied by the laboratory must follow the performance criteria and quality assurance prescribed in U.S. Environmental Protection Agency (EPA) Method TO-14/15 for canister cleaning, certification of cleanliness, and leak checking.
- Flow controllers supplied by the laboratory must follow the performance criteria and quality assurance prescribed in EPA Method TO-14/15 for flow controller cleaning and adjustment.
- Field duplicates and trip blanks (sorbent tube methods only) may be required. Check the work plan for frequency.

Attachments

- Soil Vapor Sampling Log
- Sign identifying the canisters or Bottle-Vacs as an air sample, saying “Do Not Disturb” and providing contact information.

References

U.S. Environmental Protection Agency (EPA). Office of Solid Waste and Emergency Response. 2015. *Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air*. June.

Field Operating Procedure
Soil Vapor Sampling from Exterior Soil Vapor Probes

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Field Operating Procedure Analytical Method for the Determination of Volatile Organics in Soil Vapor or Air Using the HAPSITE Field GC/MS

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Analytical Method for the Determination of Volatile Organics in Soil Vapor or Air Using the HAPSITE Field GC/MS

Purpose

This Field Operating Procedure (FOP) presents general guidelines for using a HAPSITE gas chromatograph (GC)/mass spectrometer (MS) to analyze soil vapor or air samples in the field using U.S. Environmental Protection Agency (EPA) Method TO-15 as guidance.

Scope

This is a general description of how to analyze soil vapor or air samples in the field with a HAPSITE GC/MS. This FOP is intended to be used by GC/MS chemists with proper training and experience. These procedures are based upon EPA Method TO-15, *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air*, *Second Edition* (1999), and the HAPSITE user manual. This method is applicable to specific volatile organic compounds (VOCs) in soil vapor or air. Table 1 presents a list of VOCs with reporting limits (RLs) that can be analyzed with this procedure.

Table 1. Method Analytes (1-minute fill time)

Standard Analytes	**Reporting Limit µg/m3**
1,2-DCE (cis)	2.0
1,2-DCE (trans)	2.0
PCE	3.5
TCE	2.8
Vinyl Chloride	1.3

*All RLs are subject to change on a client specified basis as requested by that client.

Equipment and Materials

HAPSITE GC/MS sampling materials:

- Inficon HAPSITE Smart, Smart Plus, or ER GC/MS
- GC Column – VOC (Standard)
- Gas sampling bags (such as Tedlar brand) in varying sizes as needed (including canister-to-bag adapter for calibration standards).
- Gastite syringes in various sizes from 25 microliters (µl) to 100 milliliters (mL) with Teflon plunger and rounded needle tip.

- Portable Windows-based laptop computer, equipped with HAPSITE Smart IQ software for acquisition, integration, quantitation, and storage of mass spectral data (including communication cable between HAPSITE and laptop). The HAPSITE can operate without connection to a computer, but a computer is necessary for higher-quality data reprocessing.
- Power source – either line power or an automobile power inverter. The HAPSITE has an onboard battery, but it needs to be re-charged periodically.
- Internal/Surrogate/Tuning Standard mix, provided with the HAPSITE in a disposable gas cylinder.
- Nitrogen Carrier Gas, provided with the HAPSITE in a disposable gas cylinder.
- Two-stage regulator for nitrogen cylinder (optional). CGA 580 fitting.
- Calibration standards – 6 liter (L) evacuated canisters prefilled with 5 parts per billion by volume (ppbV) and 0.5 ppbV of mixed gas standard for calibrating the HAPSITE and verifying calibration daily.
- Method blank standard – 6 L evacuated canister prefilled with high-purity nitrogen, to verify the HAPSITE is free of contamination daily.

Procedures and Guidelines

This FOP describes the general procedures and guidelines for using a HAPSITE GC/MS, to analyze soil vapor or air samples in the field.

Overview of the Analytical Process

- Soil vapor and air samples are collected through the sampling probe at ambient pressure.
- The HAPSITE can be operated in two different modes. Analytical mode for quantitative (quant) and qualitative results, or survey (sniff) mode for qualitative screening.
- Quant mode: Samples are introduced into the GC/MS system by way of a sample probe and concentrator. The concentrator traps the sample onto an adsorbent trap, which allows atmospheric gases to pass through (such as, carbon dioxide, oxygen, and nitrogen [N_2]). The trap is then heated, and the analytes are transferred to the GC column, then to the MS detector.
- Survey mode: Samples are introduced through the sample probe directly into the MS detector.
- Data are collected and stored into the HAPSITE system memory. The data can then be used by an external computer for calibration, data processing, reporting of samples, and data archiving.
- SIM and SCAN: The MS system can operate in SCAN or SIM mode, depending on analytical or specific project requirements. SCAN mode is used for more conventional TO-15 analysis or if tentatively identified compounds (TIC) are required. In this mode, the MS scans a range of ions (typically 35 to 250 atomic mass units). This range contains all ions necessary to identify and quantitate all compounds in the TO-15 list. If lower detection levels are required, SIM mode may be used. In SIM mode, the analyzer only looks at ions specific to the target compounds. Up to three ions are used per compound, 1 for quantitation and 1 or 2 for qualification. This increases the dwell time that the analyzer spends scanning for each specified ion, which increases sensitivity at the cost of selectivity. Because of this, it is not possible to produce TIC reports in SIM mode.
- After samples are analyzed, processed, and meet all acceptance criteria herein, a client report is generated and typically reviewed by a peer.

Target Analytes, Reporting Limits, and Detection Limits

Standard target analytes and RLs for the base analyte list for analysis in SIM mode are listed in Table 1. To keep the analysis time as short as possible, the analyte list should be kept to the minimum number of compounds of interest. To produce the analyte list and RLs in Table 1, it takes approximately 10 to 15 minutes from injection to injection (including sampling time, analytical run time, and post-run instrument cool down).

The RLs shall be at or above the lowest calibrated point on the initial calibration curve. RLs may increase or decrease based on the amount of time the sample is loaded onto the concentrator. Typical achievable limits for a 1-minute fill time are listed in Table 1 for SIM mode.

Interferences

Contamination may occur in the sampling system if it is not properly cleaned before use. Therefore, the probe should be heated and an ambient system flush performed at the start of each day, and between samples with elevated (greater than double the highest point on the calibration curve) concentrations of VOCs.

Contamination may occur from impurities in the carrier gases and from background sources. These sources of contamination are monitored through analysis of method blanks.

Cross-contamination can occur whenever samples containing high VOC concentrations are analyzed. Therefore, whenever an unusually concentrated sample is encountered (greater than double the highest point on the calibration curve), the analyst uses professional judgment when reviewing the samples to determine whether reanalysis is necessary.

Sample Collection, Storage, Holding Times, and Preservation

Samples are collected in gas sampling bags. Analysis of gas sampling bags should be performed immediately after sample collection. Samples should be field screened with a photoionization detector before analysis to obtain an approximate dilution factor.

Standards, Gases, and Reagents

All standards are logged into the chemical inventory database upon receipt. Any standard that is prepared in the laboratory will be verified against current standards before use.

- Calibration standard—Purchase a premade standard or have a vendor prepare a calibration standard in a 6-L Summa canister. Actual concentration and composition varies by project, but typically 5 ppbV and 0.5 ppbV are good targets.
  - Stock standards—Standards are purchased as custom made mixtures in gas cylinders. Cylinders purchased from vendors are traceable to a National Institute of Standards and Technology. 62-component mixture from Scott Gases (catalog number 41973-U). Stock standard is 1,000 ppbV.
  - Primary Field Standard (5 ppbV)—Dilute the 1,000-ppbV primary standard(s) 1:200. Evacuate a clean 6-L canister. Add 50 µl of DI water. Add 90 mL of 1,000-ppbV standard. Fill canister to final pressure of 2,280 torr using Ultra High Purity (UHP) N_2. This provides 12 L of usable 5-ppbV standard (16 L total).
  - Primary Field Standard (0.5 ppbV)—Dilute the 1,000-ppbV primary standard(s) 1:2000. Evacuate a clean 6-L canister. Add 50 µl of DI water. Add 9 mL of 1,000-ppbV standard. Fill canister to final pressure of 2,280 torr using UHP N_2. This provides 12 L of usable 0.5-ppbV standard (16 L total).

   - Daily Field Calibration standards—Primary Field Daily Calibration Standard—Fill a 1-L gas sampling bag with 5-ppbV primary field standard.

- Internal/Surrogate/Tuning standard—The internal/surrogate/tuning standard mix is provided with the HAPSITE in a disposable gas cylinder. Each cylinder is prepared with bromopentafluorobenzene (BPFB) and 1,3,5-tris (trifluoromethyl) benzene (TRIS) at approximately 5 ppbV, with nitrogen as the balance gas.

- Nitrogen Carrier Gas—UHP 99.999 percent or better. Either in disposable Inficon canisters or commercially provided cylinder (if HAPSITE will be used in a fixed location and large quantities are required).

Analytical Procedure

- Startup when the HAPSITE is received:

   - Unpack the HAPSITE. It is usually shipped with the power off and the MS pumped down. Be sure that it has a significant amount of time (at least an hour or overnight if possible) to warm up and equilibrate before use.

   - Insert the carrier gas (or attach external supply) and internal standard gas cylinders. Visually verify that the sample trap has not broken during shipment.

   - Plug the HAPSITE into an external power source.

   - Attach the computer (turn on and start software). Then push the power button on the HAPSITE. The HAPSITE will go through a warm up routine, then a tune. When prompted for a trap clean out, press 'yes' on the HAPSITE screen.

   - Load the desired method on the HAPSITE screen and then denote this method as the default method. This is important because otherwise it will default to a different method at the end of each run and change zone temperature settings. Note: All files (method, tune, data) reside on the HAPSITE, not the laptop computer.

- Create a new subdirectory each day. This can be done in the method editor (Data page).

   - Startup from extended standby:

      - Press power button
      - Insert internal standard and carrier gas.
      - Wait for instrument to warm up and run tune.

   - Analytical standards and/or diluted samples in gas sampling bags are attached to the sample probe manifold with a compression fitting. Ambient air samples are simply drawn directly into the probe. Pressurized or evacuated sample or standard sources cannot be used as they will significantly change instrument response.

- Quantitation Mode

   - Using the method editor on the PC, verify that the desired sample time is set correctly in the method to be used for analysis. Typically, this will be 1 minute, but may differ depending on project requirements or dilutions. Save the method.

   - Load the appropriate quantitation method onto the HAPSITE. This can either be done from the touch screen or the PC. Be sure that the method is appropriate for the target compounds.
     If necessary, sensitivity can be increased by using SIM to target the most important ions of interest.

  - Run the quality control (QC) (either an initial calibration [ICAL] or calibration verification [CV] and blank). Attach a gas sampling bag containing the standard or UHP blank gas to the sample probe. Open the bag and press run on the HAPSITE. Once QC has passed criteria, then sample analysis can begin.
  - Attach a gas sampling bag containing the sample to the sample probe and press the run button on the HAPSITE. Once the desired sample time has been completed, the gas sampling bag can be removed.
  - Once the analysis is complete, allow the GC oven to cool, then inject the next sample.
  - All the sample and QC information for an analytical run, such as laboratory and client sample identifications (IDs), injection volumes, standard IDs, and run methods, are added to the field log.
- Sample Dilution
  - Any sample that has target analytes over the calibrated range of the instrument should be diluted if possible. The subsequent dilution should be run such that the final value of the maximum concentration analyte recovers within the calibrated range on the instrument (before dilution factors are applied).
  - Required dilutions for HAPSITE analysis can be achieved in two different ways:
    - Concentrator fill time: Inject a smaller sample volume. Record all dilutions in the field form. For example, normalized to a 1 minute fill time (100 mL), a dilution of 5 times can be performed by only sampling for 0.2 minute (20 mL). Using the method editor on the PC, set the desired sample time in the method to be used for analysis. Save the method. Then load the appropriate quantitation method onto the HAPSITE. This can either be done from the touch screen or the PC
    - Gas sampling bag dilution: Take a sample with a syringe and inject it into a gas sampling bag with a known volume of clean air. Attach the bag to the instrument sampling port and withdraw an aliquot. The aliquot can be less than the normalized value (as in the section before). Both the gas sampling bag dilution factor and concentrator fill injection factors are applied to the final instrument result.
- At the end of the day, put the HAPSITE into external standby and remove carrier gas and internal standard (ISTD) if the instrument is going to be used again next day. Otherwise, the HAPSITE can be powered off.

Quality Control and Quality Assurance

All RLs, QC frequency, and QC acceptance criteria are subject to change on a project specific basis.

- The instrument is tuned using BPFB and TRIS. This is performed before analysis each day. The HAPSITE software runs a tuning program set to optimize its instrument parameters for analysis. This program optimizes sensitivity and enables library matching of the spectra.
  - There are short- and long-tune algorithms. Typically, the short tune is performed. A long tune is performed only after major instrument maintenance.
  - After running a successful tune (tune passes internal instrument criteria), it is saved to the default tune file.
  - The HAPSITE is not designed to pass the TO-15 bromofluorobenzene (BFB) tune criteria to operate at its highest potential. Therefore, BFB tune criteria are not relevant for this FOP.

- Initial Calibration—An initial calibration curve is required to demonstrate adequate instrument performance for sensitivity, linearity, resolution, and absence of active sites.
  - A valid initial calibration curve must be established before samples can be analyzed. The GC/MS is calibrated following the outline herein. Variations from this standard calibration scheme are sometimes necessary because of project RL requirements.
  - As the RL is driven by the lowest calibration point, any lowering of the RL will require either (A) calibrating to a lower level or (B) injection of more sample volume.
  - Calibration schemes.
  - The following calibration schemes have been successfully used, the actual scheme used should be tailored to the instrument and project requirements. It is based on a 1-minute sampling period (1 minutes at 100 mL/min = 100 mL)

    Cal Levels (1-minute sampling time normalization)

Cal level	Std Concentration, ppbV	Sampling time, min.	Concentration, ppbV
Level 1	0.5	0.2	0.1
Level 2	0.5	1.0	0.5
Level 3	0.5	2.0	1.0
Level 4	5.0	1.0	5.0
Level 5	5.0	5.0	25.0

  - The curve can be shifted to be more or less sensitive by increasing or decreasing the sampling time. Longer sampling time increases sensitivity, and vice versa.
  - For the initial calibration, a response factor and a percent relative standard deviation (%RSD) are calculated for each analyte.
  - After a new calibration is performed, the method needs to be saved with the correct filename. The method name should be the date followed by an identifier. For example, an ICAL performed on October 29, 2014, for client X shall be named 102914X.
  - There must be at least three points to have a valid calibration curve. The lowest point will be below the quantitation limit required in the Quality Assurance Project Plan.
  - The %RSD for all compounds must be less than 30 percent.
  - If the %RSD greater than 30 percent, then a linear curve fit may be used if the curve fit greater than 0.995.
    - If the requirements are not met, then a new initial calibration must be performed. If this does not result in an acceptable initial calibration, then system maintenance may be necessary.
    - Calibrations are valid for 1 year (or until the end of the project, whichever occurs first) if QC continues to meet acceptance criteria.
    - In the following instances, a new calibration shall be required:

      Major instrument maintenance such as cleaning the MS.

      Repeated failure (more than 3 attempts) to pass continued calibration criteria.

- Method Blanks—Method blanks are required at a rate of one per day. Method blanks are analyzed to monitor possible instrument contamination. Laboratory method blanks are prepared with UHP nitrogen in a gas sampling bag every day samples are to be analyzed. The method blank is carried through the same analytical procedure as a field sample.
  - Method blanks are analyzed by injecting the full normalized volume of nitrogen (varies by system) into the HAPSITE and following procedures outlined in Section 9.
  - The blank must not contain any target analyte at a concentration greater than the RL and must not contain additional compounds with elution characteristics or mass spectral features that would interfere with identification and measurement of a method analyte. If target analytes are found in the method blank above the RL, the source of the contamination must be considered. Usually, rerunning the blank will resolve most problems (especially if the sample run prior to the blank was high in target analyte concentration). If blank contamination is still present, the analyst must perform system maintenance. Some common problems that cause a blank to show contamination are:
    - Cold spots—check heated zones for failure
    - Contaminated sample probe—flush the probe
    - Dirty gas sampling bag—flush and refill the bag or use new bag
- Continuing Calibration Verifications—a primary source standard analyzed at the beginning of an analytical batch to ensure that the instrument continues to meet the instrument sensitivity and linearity requirements originally established by the initial calibration.
  - The opening CV for each compound of interest shall be verified prior to sample analysis using the same introduction technique and conditions as used for samples. This is accomplished by analyzing one of the calibration standards used for initial calibration.
  - Concentrations for CV must be at or below the midpoint of the instrument calibration curve.
  - No closing calibration check is required for TO-15 analysis. However, a closing calibration check will be analyzed to increase confidence in data quality.
  - The percent difference (%D) for each compound may not exceed 30 percent.
  - Failure to pass continuing calibration criteria requires corrective action are performed. Repeated failure (more than 3 consecutive attempts) to pass response factor criteria requires the performance of a new initial calibration.

Attachments

- HAPSITE Log Sheet – Quant Mode
- HAPSITE Log Sheet – Sniff Mode

References

U.S. Environmental Protection Agency (EPA). 1999. *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, Second Edition*. January.

Infilcon. 2017. Operating Manual: HAPSITE ER Chemical Identification System. IPN 074-471-P1D.

Infilcon. 2008. Operating Manual: HAPSITE Smart Plus Chemical Identification System. IPN 074-472-P1D. November.

HAPSITE Log Sheet
Quant Mode

Project: ______________________

Date: ______________________

Operator: ______________________

SubDirectory: ______________________

Sample ID	Time	File ID	Fill Time	Dilution Factor	Notes

Notes: ______________________

HAPSITE Log Sheet
Sniff Mode

Project: ______________________
Date: ______________________
Operator: ______________________
SubDirectory: ______________________
General Location: ______________________
Start Time: ______________________

Location	Time	Notes

Notes: ______________________

Field Operating Procedure
Equipment Decontamination

Prepared by: Jennifer Simms **07/07/2017**

Jen Simms

Author

Reviewed by: Brett Fishwild **date**

Site Manager

Approved by: Kimberly Amley **07/07/2017**

Kimberly Amley

Project Quality Manager

Equipment Decontamination

Purpose

This Field Operating Procedure (FOP) provides general guidelines for the decontamination of personnel, sampling equipment, and monitoring equipment used in potentially-contaminated environments.

Scope

This FOP provides a general description of decontamination procedures.

Equipment and Materials

- Distilled or deionized water
- 2.5 percent Liquinox, or equivalent phosphate-free detergent (not Alconox) and water solution
- Large plastic pails or tubs for Liquinox and water, scrub brushes, squirt bottles for detergent solution, resealable plastic bags, and paper towels
- 55-gallon drum for disposal of waste, approved by the U.S. Department of Transportation (DOT)
- Chemical-resistant gloves (that is, nitrile gloves)
- Aluminum foil

Procedures and Guidelines

This FOP describes the general guidelines for the decontamination of personnel, sampling equipment, and monitoring equipment used in potentially contaminated environments.

Personnel Decontamination

The following procedures are to be performed after the completion of tasks, when the potential for contamination exists, and upon leaving the exclusion zone:

1. Wash boots in detergent solution, and then rinse with water. If disposable latex booties are worn over boots in the work area, remove and discard into a DOT-approved 55-gallon drum.
2. Remove and discard outer chemical-resistant gloves into a DOT-approved 55-gallon drum.
3. Remove disposable coveralls (Tyveks) and discard into a DOT-approved 55-gallon drum (if worn).
4. Remove respirator (if worn). Dispose of filter cartridges and replace daily.
5. Remove inner gloves and discard.
6. Shower entire body at the end of the work day, including hair, either at the work site or at home.
7. Sanitize respirator if worn.

Sampling Equipment Decontamination—Other Equipment

Reusable sampling equipment is decontaminated after each use as follows:

1. Wear chemical-resistant gloves.

2. Rinse and scrub with potable water.
3. Wash all equipment surfaces that come into contact with potentially contaminated soil and water with detergent solution.
4. Rinse with potable water.
5. Rinse with distilled water.
6. Completely air dry or wipe dry with a clean paper towel. Wrap exposed areas with aluminum foil (shiny side out) or enclose equipment in clean plastic for transport and handling if equipment will not be used immediately.
7. Collect all rinsate and place in a DOT-approved 55-gallon drum.
8. Dispose of decontamination materials (for example, plastic sheeting and tubing) that have come into contact with used decontamination fluids or sampling equipment in DOT-approved 55-gallon drums.

Health and Safety Monitoring Equipment Decontamination

1. Wrap soil contact points in plastic before use, to reduce need for subsequent cleaning.
2. Wipe all surfaces that had possible contact with contaminated materials with a paper towel wet with detergent solution, and finally two times with a towel wet with distilled water.
3. Dispose of all used paper towels in a DOT-approved 55-gallon drum.

Sample Container Decontamination

The outside of sample bottles or containers filled in the field may need to be decontaminated before being packed for shipment or handled by personnel without hand protection. The procedures for sample container decontamination are as follows:

1. Wipe container with a paper towel dampened with detergent solution, or immerse in the solution **after the containers have been sealed.** Repeat the above steps using potable water.
2. Dispose of all used detergent solution and paper towels in a DOT-approved 55-gallon drum or in trash bags placed into appropriate dumpsters, keeping liquids and solids in separate drums.

Quality Control and Quality Assurance

Record equipment decontamination procedures in the field logbook.

The field logbook will be reviewed by the field quality manager each day.

Attachments

None.

References

None.

Field Operating Procedure Building Surveys For Vapor Intrusion Investigations

Prepared by: Jennifer Simms **07/07/2017**

Jen Simms

Author

Reviewed by: Brett Fishwild **date**

Site Manager

Approved by: Kimberly Amley **07/07/2017**

Kimberly Amley

Project Quality Manager

Conducting Building Surveys for Vapor Intrusion Investigations

Purpose

This Field Operating Procedure (FOP) presents general guidelines for conducting building surveys for vapor intrusion (VI) investigations. A building survey is performed as part of a VI investigation to obtain information for development of the building-specific aspects of a conceptual site model (CSM) and to prepare for VI sampling (for example, select optimal sampling locations and determine if there are potential confounding indoor sources of volatile organic compounds [VOCs]).

A CSM for VI pathway investigation describes potential VOC subsurface sources, migration pathways, and potential human receptors under current and/or future land uses at the site. The important building characteristics for VI pathway investigation include the following:

- Building use and occupancy
- Condition of the building envelope
- Presence of a basement or crawl space
- Presence of preferential pathways for vapor intrusion
- Dimensions of the building and interior compartments
- Condition of the slab and basement walls and presence of potential VI pathways
- Type, zoning, and typical operational settings of the heating, ventilation, and air conditioning (HVAC) system
- Presence of potential indoor sources of VOCs
- Evidence of groundwater infiltration into the structure

This FOP can be used to perform building surveys in residential, commercial, or industrial buildings.

Scope

This FOP provides a general description of the information that should be observed and documented during building surveys. Sources of information about the building can include conversations with the occupants, landlords, visual observations, and possibly building plans or building inspection reports the occupant may be willing to share. The level of detail to which each building characteristic is evaluated will depend on the data quality objectives for each project.

Equipment and Materials

- CH2M HILL, Inc. (CH2M) Building Survey Form – to record survey information. Either electronic or paper.
- Figure showing the footprint of the building (if available) – to mark up during the building survey
- Flashlight

- Laser measuring tool, walking wheel, or measuring tape – to measure building and room dimensions
- Camera – to photograph the building (interior and exterior)
- Field instrument for measuring indoor air VOC concentrations (optional) – to identify potential indoor VOC sources

Procedures and Guidelines

Procedures for Performing a Building Survey

- **Gain access to the building**. Field staff should be trained for their role in courteous public interaction, aware of common safety hazards that may exist in buildings, and work closely with risk communication specialists.
- **Obtain occupant information**. The building occupants are the potential receptors in the VI CSM. Is the building use residential, commercial, or industrial? How many people typically occupy the building? Are there sensitive receptors (children, elderly, pregnant women, or immune-impaired) in the building? How much time do occupants spend in the building? What areas of the building do the occupants typically use (that is, where do they spend the most time)? If there is a basement, it is helpful to understand the amount of time people spend in the basement – for example, is there a family room in it or is it just storage or laundry?
- **Obtain building information.** How old is the building? What was its original use? Have there been additions or other significant modifications? Additions will likely have slabs that are separate from the original building. Differing shingles or roof pitches can sometimes indicate additions as well. How many floors does the building have? Does the building have a basement? If so, how far does it extend below grade? Is the slab on grade? Is the slab elevated above the ground surface? Is there a crawlspace? If so, where is the crawlspace access?
- **Survey the building envelope**. Walk around the inside and outside of the building and record information on the building construction and condition. How many doors/windows/loading docks are there, what condition are they in, and are they typically left open or closed? Are there obvious cracks in the walls or at the eaves that provide ventilation? What are the building construction materials? Look up at the roof for signs of a whole-house fan or other exhaust ventilation. Observe any exhaust fans that may be present in the walls or ceilings.
- **Determine the indoor air volume and the location and volume of separate indoor air compartments within the building**. Measure the building dimensions (length, width, and height). Measure the dimensions of compartments or rooms within the building. How are rooms connected? Are interior doors typically kept open or shut? Are there separate compartments within the building (that is, areas that are not connected to other areas such that the indoor air does not mix)?
- **Observe the slab condition**. How thick is the slab? What is the general condition of the slab? What is the floor covering in each room of the lowest floor (carpet, tile, or wood)?
- **Identify potential vapor intrusion pathways**. Any openings, cracks, or penetrations in the slab or basement walls may be entryways for subslab soil vapor.

  Are there utilities that penetrate the slab or basement walls? Are they sealed properly? It may be helpful to inventory utilities systematically by asking where the water line comes in, and where the sewage line goes out. Ask if the building has central utility services for water and sewer or uses septic and/or well. Similarly, telecommunications, cable TV, and power lines can come into the building overhead or underground. Overhead services can frequently be identified on the exterior of the structure and are unimportant for vapor intrusion. Underground services can either be directly buried wire/cable or installed in a conduit.

Are there cracks in the slab or basement walls? If so, note where these cracks are and their approximate size. Are there sumps? If so, note the dimensions of each and their typical operating conditions (is pump present? Is the top of the sump sealed? Where does the sump discharge?). Is the wall/floor juncture sealed well? Is there a french drain? Is there an open drain provided in the laundry room or for draining water from the furnace or gas fired hot water heater? Has the basement been waterproofed? Are there expansion joints in the slab? If so, note their condition.

- **Evaluate the HVAC system**. Record the type and model of the systems and the typical operating conditions. Is there one air conditioning zone or multiple zones (look for multiple thermostats)? Does the HVAC system use radiant heat or forced air? If the HVAC system is forced air, where are the heating and cooling and return air vents? Where is the HVAC system's fresh air intake? What is the heating fuel source (that is, natural gas, oil, or propane)? Are there ventilation fans (such as bathroom exhaust, kitchen exhaust and/or whole house fans)? If so, note where and their typical operating conditions. Are there window air conditioning units? Is a heat recovery ventilator in use? Is there a fireplace or woodstove, and if so how frequently is it used?
- **Identify any existing vapor mitigation systems.** Is there a radon mitigation system or other subslab depressurization system? Is there sealant on any cracks or crevices? Is there a sealant coat on the floor or basement walls for vapor or water mitigation?
- **Identify if the building experiences seasonal flooding**. Ask the building owner and/or occupants if seasonal flooding in the building is experienced. If so under what conditions/how frequently/how bad? If the building experiences flooding, document the condition of gutters/downspouts and whether the lot is graded away from the foundation. This will help assess the source of the water.
- **Sketch the building floor plan**. Include building dimensions, locations of windows/doors/loading docks, outdoor surface cover (such as, grass and asphalt), and locations of potential indoor or outdoor VOC sources. Attached garages or attached storage sheds can be important sources of VOCs. Fully detached garages or storage buildings do not normally need to be surveyed unless they are routinely occupied.
- **Identify potential indoor VOC sources within the building**. Record the location of the potential sources and determine if they can be removed before indoor air sampling is performed. Potential indoor sources of VOCs may include cleaning products, paint, dry-cleaned clothes, craft glues, air fresheners, gasoline, cosmetics, or cigarette smoke. Recent remodeling activities, including painting, installing new carpeting or flooring, and moving in new furniture should be identified, because they could be potential sources of VOCs. A field instrument can also be used to pinpoint potential indoor VOC sources. In situations with numerous products such as numerous cleaning supplies, it can be efficient to photograph both the front and back of the containers lined up.
- **Identify potential outdoor contaminant sources**. These may include gas stations, major roadways, dry cleaners, repair shops, industries, outdoor cooking areas, or landfills.
- **Identify possible indoor air, outdoor air, crawl space air, and subslab soil vapor sample locations** that meet the project-specific data quality objectives and are acceptable to building occupants.

Quality Control and Quality Assurance

Adequate time should be reserved for performing building surveys and detailed notes should be recorded at the time of the building survey. Verify that indoor air samples are collected no less than

24-hours after chemical products that may contain VOCs are temporarily removed from the building. The field notes should be reviewed by the Field Quality Manager at the end of each work day performed.

Attachments

- CH2M Building Survey Form

References

Interstate Technology and Regulatory Council. 2007. V*apor Intrusion Pathway: A Practical Guideline. Prepared by The Interstate Technology & Regulatory Council Vapor Intrusion Team*. Available at http://www.itrcweb.org/documents/VI-1.pdf.

U.S. Environmental Protection Agency. Office of Solid Waste and Emergency Response. 2015. *Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air*. June.

Building Survey Form for Vapor Intrusion Investigations

Property ID: ______________________________

Site/Project Name: ______________________________

____

Date of Survey: ______________________________

Preparer(s): ____

Building Occupancy and Use

1. What is the estimated number of building occupants?

____

____

(Make general observations about age range and percentage of male to female ratio)

2. Are there any sensitive receptors in the building? (elderly, children, immuno-compromised, women of child bearing age, etc.)

____

3. How long have the current occupants occupied the building? ______________________________

4. What is the building type/use? Circle all that apply and describe.

Residential (single family, duplex, apartments) / Office / Strip Mall / Commercial / Industrial / Other:

____

Describe building use (circle all that apply):

Residential / Manufacturing / Storage / Chemical Storage / Administrative / Instrumentation / Other:

____

____

5. What are the historical activities within the building (if different than above)?

____

____

Building Occupancy and Use - continued

Questions 6 - 8 are applicable to non-residential buildings only.

6. What type of work is performed within the building? ______________________________

7. How many hours per day or week do workers spend in the building?

8. Is the building accessed by the public? (Describe approximate number of persons, frequency of visits, and duration of visits.)

Building Construction

1. What year was the building constructed? ______________________________

2. Have there been additions to the building? If so, when? (Identify on building sketch)

3. What are the approximate dimensions of the building? ______________________________

4. What are the construction materials of the exterior of the building?

5. How many floors does the building have? ______________________________

Does the main floor sit on, below, or above grade? ______________________________
(How many feet above or below grade?)

Number of floors at or above grade? ______________________________

Number of floors below grade? ______________________________
(How many feet below grade?)

Building Construction - continued

6. Describe the basement (if present):

Does the building have a basement and/or crawl space? ______________________

____

How many feet below grade? ______________________

Approximate square footage: ______________________

Approximate ceiling height (give range if varying height): ______________________

Is the basement separated into multiple rooms? Describe (note use, if space is finished/unfinished):

____

____

Construction materials of walls (i.e. poured concrete, cinderblock, brick, etc.; are the walls covered with epoxy?):

____

Are significant cracks present in the walls? ______________________

7. Describe the main floor:

Approximate square footage: ______________________

Approximate ceiling height (give range if varying height): ______________________

Is the main floor separated into multiple rooms? ______________________

____

____

Construction materials of walls (i.e. framing, siding, cinderblock, etc.):

____

____

Building Construction - continued

8. Describe the building slab:

Construction materials of floor/slab: ______________________________

____

Describe the floor coverings (epoxy paint, carpet, tile, etc.) ______________________________

____

If concrete slab, are expansion joints present? ______________________________

Are they sealed/showing deterioration? ______________________________

Are significant cracks present in the slab? ______________________________

Are there any penetrations in the slab? (utility conduits, etc.) ______________________________

____

Is there a subslab vapor/moisture barrier in place? ______________________________

Are any floor drains or sumps present? Is there standing water in them? ______________________________

____

Are there any subsurface vaults present? (if so describe and add locations to building sketch)

____

9. Does the building have a moisture/dampness problem?

No / Rarely (less than 1 time per year) / Occasionally (1-2 times per year) / Frequently

10. Does the building ever flood?

No / Rarely (less than 1 time per year) / Occasionally (1-2 times per year) / Frequently

11. Is there a septic system? ☐ Yes ☐ Yes, but not in use ☐ No

12. Is there irrigation or a private well? ☐ Yes ☐ Yes, but not in use ☐ No

13. Type of ground cover outside: Grass / Concrete / Gravel / Asphalt / Other ______________________________

14. Additional notes on building construction:

____

____

____

Existing Vapor Mitigation Systems

1. Has a radon or vapor mitigation system been installed in this building? (Show location on building sketch)

____

If yes: Installation Date: ______________________

Type of System: Passive Venting / Active Subslab Depressurization
Crack and Crevice Sealing / Dilution Ventilation Control / Other

Notes: ______________________________

Air Flow Within the Building and Outdoor Air Exchange

1. Are there any areas of the building that are positively or negatively pressurized (look for doors not opening and/or closing properly, perceptible air flow, audible fan noises)?

____

____

____

2. Is there one HVAC zone or multiple zones? How many zones? Add thermostat locations to building floorplan, if available.

____

____

____

3. Type of ventilation system (circle all that apply):

Central Air Condition / Mechanical Fans / Bathroom Ventilation Fans / Individual Air Condition Units
Kitchen Range Hood Fan / Outside Air Intake / Industrial Floor Fans
Whole-Building Attic Exhaust Fan / Other: ___________________________________

4. Type of heating system (circle all that apply):

Forced Hot Air / Hot Air Radiation / Wood / Steam Radiation / Heat Pump / Individual Heater / Hot Water Radiation
Kerosene Heater / Fireplace / Electric Baseboard / Other: ____

5. Type of fuel utilized (circle all that apply):

Natural Gas / Electric / Fuel Oil / Wood / Coal / Solar / Kerosene / Other: ____________________________________

6. Are there any sources of outdoor air?

☐ Mechanical (AHU) ☐ Doors

☐ Windows ☐ Other

Are windows/doors left open routinely (seasonal differences)? ______________________

Evaluation of Potential Indoor VOC Sources

1. Are SDSs available for chemicals used with in the building? If possible, obtain a copy of the Table of Contents. List items in additional notes section (include approximate quantities and frequency).

☐ Yes ☐ No

2. Do any of the products stored in the building contain VOCs?

☐ Yes ☐ No

3. Are any of the target analytes used in the building?

☐ Yes ☐ No

If yes, is the usage confined to a specific room/area?

☐ Yes ☐ No

____

____

4. Are pesticides used for indoor pest control?

☐ Yes ☐ No

If yes: Name of product: ______________________

Frequency of use: ______________________

Has there been an application within the last 6 months? ______________

5. Is smoking permitted inside the building?

☐ Yes ☐ No

If yes, does smoking typically occur within a specific room/area?

☐ Yes ☐ No Notes: ______________________

How often? ______________________

Last time someone smoked in the building? ______________________

6. Has there been any remodeling or construction within the past 6 months (i.e. new carpeting/tiling, painting, additions, new furniture, etc.)

☐ Yes ☐ No

____

____

____

Is there any planned for the near future?

☐ Yes ☐ No

____

____

Evaluation of Potential Indoor VOC Sources - continued

7. Does the building have an attached garage or do vehicles regularly enter the space (example: a vehicle repair shop)?

☐ Yes ☐ No

____

8. Are gas-powered equipment or cans of gasoline/fuels stored in the building or attached garage?

☐ Yes ☐ No

____

9. Do building occupants dry clean their clothes? ☐ Yes ☐ No

If yes, how often? Weekly / Monthly / Infrequently (3-4 times a year)

10. Has there ever been a fire in the building? ☐ Yes ☐ No

11. Has there ever been a known chemical spill immediately outside or inside the building?

☐ Yes ☐ No

12. Was the building screened with a ppbRAE to identify indoor VOC sources? If yes, describe the results:

☐ Yes ☐ No

____

____

____

____

____

Evaluation of Potential Outside VOC Sources

1. Are there stationary sources nearby (i.e. gas stations, emission stacks, hazardous waste storage, etc.):

☐ Yes ☐ No

____

____

2. Is there heavy vehicular traffic nearby (or other mobile sources)?

☐ Yes ☐ No

____

____

Building Survey Form for Vapor Intrusion Investigations

Attachment 1 - Confidential Information

Building Location:

Property ID: ____________________

Address: ____________________

____

Business Name (if applicable): ____________________

Contact Information:

Name(s): ____________________

Occupation/Role: ____________________

Phone Number: (Home or Office) ____________________ (Mobile) ____________________

E-mail Address: ____________________

Name of person being interviewed, if different than above: ____________________

Do the occupants rent or own the building? ____________________

Provide owner contact information if different from above:

Name(s): ____________________

Phone Number: (Home or Office) ____________________ (Mobile) ____________________

E-mail Address: ____________________

Building Survey Form for Vapor Intrusion Investigations

Attachment 2 - Room-Specific Information

Questions from the generic building survey may apply to individual rooms if the building is partitioned into separate work spaces, especially if work spaces differ in daily activities. Please include room name and any applicable details below. If available, add room names to building floor plan for future reference.

> Example: Women's Restroom (Room 112A) - Room measurements are 7' long, 5' wide, and 9' high. Typical cleaning supplies stored under sink (including products XYZ). Exhaust fan in ceiling that only runs when room is in use. One floor drain in center of room. Floor is tiled, so slab is unable to be observed. No cracks in walls. Room recently painted (approximately 3 months ago, as of survey date). Window unit dedicated to the room.

Building Survey Form for Vapor Intrusion Investigations

Attachment 3 - Additional Notes

If additional room is needed for capturing information collected during the building survey, include all notes here:

Field Operating Procedure Installation and Abandonment of Vapor Pins as Subslab Soil Vapor Probes

Prepared by: Jennifer Simms **07/07/2017**

Jen Simms

Author

Reviewed by: Brett Fishwild **date**

Site Manager

Approved by: Kimberly Amley **07/07/2017**

Kimberly Amley

Program Quality Manager

Installation and Abandonment of Vapor Pins as Subslab Soil Vapor Probes

Purpose

This Field Operating Procedure (FOP) presents general guidelines for installing and abandoning Cox-Colvin & Associates, Inc. (Cox-Colvin), Vapor Pins as subslab soil vapor probes.

Scope

This is a general description of how to install Vapor Pins as permanent or temporary subslab soil vapor probes, and how to abandon them when sampling is complete.

Equipment and Materials

Vapor Pin installation materials:

- Rotary hammer drill and drill bits (1.5-inch and 5/8-inch diameter).
  - The 5/8-inch diameter drill bit should be long enough to drill through the thickness of the slab.
  - The 1.5-inch drill bit is only necessary for installation of permanent subslab soil vapor probes so they can be finished with a flush-mount cover.
  - Optional: Cox-Colvin countersink drill bit. Can be used in high traffic areas to facilitate a true flush-mount installation of the stainless steel secure cover.
- Vacuum cleaner (shop-vac-type, with both a dust bag and high-efficiency particulate air [HEPA] filter) for removing concrete dust generated while drilling through the slab.
- A dust collection shroud to minimize dust during drilling. This can either be an on-board system that covers the whole drill bit, or a universal shroud that covers the hole.
- Photoionization detector (PID) to measure total volatile organic compound (VOC) concentrations in the breathing zone for health and safety while drilling
- Power extension cord with multiple outlets and ground fault circuit interrupter
- Laser measuring tool, walking wheel, or measuring tape – to measure the location of the probe
- Assembled Vapor Pin (Vapor Pin and silicone sleeve)

Figure 1. Assembled Vapor Pin

- Vapor Pin 3/4-inch bottle brush

- Vapor Pin white protective caps
- Vapor Pin installation/extraction tool
- Vapor Pin stainless-steel drilling guide (optional for permanent installation method)
- Traffic cone (optional for protecting stick-up probes)
- Dead-blow hammer or rubber mallet
- Vapor Pin black plastic or stainless-steel secure cover (optional for permanent probes)
- Vapor Pin spanner screwdriver for secure cover

Vapor Pin abandonment materials:

- Vapor pin installation/extraction tool
- Cement patch
- Trowel for applying cement patch

Procedures and Guidelines

This FOP describes the general guidelines for installing and abandoning Vapor Pins as subslab soil vapor probes.

Procedures for Installing Vapor Pins:

- A private utility clearance must be performed prior to drilling through the slab, as with all intrusive site work. The private utility clearance should be performed with a concrete scanner (small, handheld ground-penetrating radar unit designed for "seeing through" concrete slabs) to identify utilities, wire mesh, and/or rebar in the slab prior to drilling. A public utility locate may also be necessary depending on the site. The public utility clearance will only be completed outside of the building and/or property. In buildings where radiant floor tubing is in the slab, infrared scanning may also be necessary.
- Temporary stick-up soil vapor probes (**Figure 2**):
  - Drill a 5/8-inch diameter hole through the entire concrete slab with the rotary hammer drill while continuously vacuuming through the dust collection shroud.
  - Drill approximately 3 inches down into the subslab material to create a void space that is free of obstructions that might plug the probe during sampling.
- Permanent flush-mounted probes (**Figure 2**):
  - The slab must be at least 3.5 to 4 inches thick to install a permanent flush-mounted probe.
    - If the thickness of the slab is unknown, then the 5/8-inch diameter hole should be drilled through the entire concrete slab first determine the slab thickness.
    - However, if the slab is known to be at least 3.5 to 4 inches thick, then the 1.5-inch diameter hole may be drilled first.
  - Drill a 1.5-inch-diameter hole to a depth of 1.75 inches with the rotary hammer drill while continuously vacuuming through the dust collection shroud.
    - Optional - use the drilling guide to measure the hole depth.
    - If a true flush-mount installation is required, the Cox-Colvin countersink bit can be used to drill both the 1.5-inch-diameter hole as well as the 2-inch diameter 1/8-inch deep counter sink.

  - Drill a 5/8-inch diameter hole through the rest of the concrete slab with the rotary hammer drill while continuously vacuuming through the dust collection shroud.
  - Drill approximately 3 inches down into the subslab material to create a void space that is free of obstructions that might plug the probe during sampling.
- Note the approximate thickness of the slab.
- Measure VOC concentrations in the breathing zone when drilling through the slab to ensure the project's health and safety requirements are met.

Figure 2. Permanent Flush-mounted Probe and Temporary Stick-up Probe

- Record the approximate thickness of the slab, the approximate depth drilled beneath the slab, and the observed subslab material in the field logbook.
- Clean out the hole with the Vapor Pin bottle brush and the shop vac.
- Install the Vapor Pin into the hole with the installation and extraction tool and dead-blow hammer or rubber mallet. During installation, the silicon sleeve will form a slight bulge between the slab and the Vapor Pin shoulder. Place the white protective cap on the Vapor Pin.
- Permanent flush-mounted probes – place either the black plastic or stainless steel secure cover over the Vapor Pin. Tighten the stainless steel secure cover using the spanner wrench.
- Temporary stick-up probes – place a traffic cone over the probe to protect people from tripping over it.
- Measure the location of the probe from two perpendicular exterior walls using the laser measuring tool, walking wheel, or measuring tape. Record the probe location in the field logbook or on a building layout figure.
- Wait at least 2 hours after installation is complete before purging, leak testing, and collecting subslab soil vapor samples to allow the subsurface to equilibrate.

Procedures for Abandoning Vapor Pins:

- Remove the traffic cone for temporary stick-up probes, or remove the black plastic cover or stainless steel secure cover with the spanner wrench.
- Remove the Vapor Pin from the hole with the installation/extraction tool.
- Fill the hole with concrete patch and smooth the surface with the trowel.

Quality Control and Quality Assurance

Verify the purge and leak testing passes controls before collecting the subslab soil vapor samples. The field notes should be reviewed by the field quality manager at the end of each work day performed.

References

U.S. Environmental Protection Agency. Office of Solid Waste and Emergency Response. 2015. *Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air*. June.

Cox-Colvin & Associates, Inc. (Cox-Colvin). 2016. *Standard Operating Procedure – Installation and Extraction of the Vapor Pin*. September.

Cox-Colvin & Associates, Inc. (Cox-Colvin). 2016. *Standard Operating Procedure – Countersink Drill Bit for Flush Mount Installation of the Vapor Pin*. August.

Field Operating Procedure
Subslab Soil Vapor Sampling From Vapor Pins

Prepared by: Jennifer Simms **07/07/2017**

Jen Simms

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Reviewed by: Brett Fishwild **date**

Site Manager

Approved by: Kimberly Amley **07/07/2017**

Kimberly Amley

Project Quality Manager

Subslab Soil Vapor Sampling from Vapor Pins

Purpose

This Field Operating Procedure (FOP) presents general guidelines for collecting subslab soil vapor samples from Cox-Colvin & Associates, Inc. (Cox-Colvin), Vapor Pins; methods for purging and leak-checking the Vapor Pins are also included in this FOP. The number, location, analytical method (including sampling container), and sampling duration of subslab soil vapor samples should be determined on a project-specific basis. A building survey is typically performed before sampling to obtain building characteristic information.

Scope

This is a general description of how to purge and leak test Vapor Pins and then collect subslab soil vapor samples. This FOP describes sampling with evacuated canisters and additional optional sampling methods including Bottle-Vacs, Tedlar bags, and sorbent tubes.

Equipment and Materials

Purge and water dam leak-check:

- Vacuum pump with rotometer to control flow to 200 milliliters per minute (mL/min)
- Water
- Vapor Pin water dam
- Volatile organic compound (VOC)-free modeling clay (like Play-Doh)
- Paper towels
- Turkey baster or large plastic syringe (for removing water from the water dam)
- Three-way sampling manifold consisting of Swagelok gas-tight fittings with three valves and one vacuum gauge to attach the probe to the vacuum pump and the sample canister
- Teflon tubing, 0.25-inch outer diameter
- Flexible silicon tubing (3/8-inch inner diameter to connect Teflon tubing from Vapor Pin)
- 1-liter Tedlar bag to collect the purged soil vapor so: (1) it is not discharged into the building; (2) the approximate volume of purged soil vapor can be measured; and (3) field screening can be performed on the purged soil vapor
- Photoionization detector (PID; MiniRae or MultiRae) to monitor breathing zone VOC concentrations. It is also optional to collect field measurements of total VOCs from the purged soil vapor; may warn the laboratory if high concentrations are detected so they can dilute the sample before analysis.
- LandTec GEM Landfill Gas Meter (optional) to collect field measurements of oxygen, carbon dioxide, and methane

Subslab soil vapor sampling with evacuated canisters:

- Stainless-steel sample canister(s) certified clean and evacuated (canisters are cleaned, evacuated, and provided by the laboratory.) Note that separate canisters of the same size may be designated by the laboratory for use in collecting subslab soil vapor samples versus indoor air, outdoor air, and crawlspace air samples and may been certified in different manners. It is important to make sure that canisters are used for their designated sample type.

- Flow controller(s) set at desired sampling rate. (Flow controllers are cleaned, set, and provided by the laboratory.)
- Analog pressure gauge dedicated to the canister may be permanently attached to either the canister or flow controller. This pressure gauge will be used to monitor the canister pressure during sampling.
- Digital pressure gauge with a -30 to 0-inch mercury (Hg) range, and 0.50-inch Hg accuracy, which should be verified annually. This pressure gauge should have a Swagelok 1/4-inch female connection because it will be used to measure the initial and final canister pressure. Digital gauges should not be shared between soil vapor samples and air samples (indoor, outdoor, or crawlspace) to prevent cross-contamination.
- Wrenches and screwdriver, various sizes as needed for connecting fittings. A 9/16-inch wrench fits the 0.25-inch Swagelok fittings, which most canisters and flow controllers have.
- Swagelok nut and ferrule set (part #SS-400-NFSET) to connect tubing to the sampling manifold
- T-connector (provided by the laboratory) for collecting simultaneous duplicate samples.
- Shipping container, suitable for protection of canister(s) during shipping. Typically, strong cardboard boxes are used for canister shipment. The canisters should be shipped to the laboratory in the same shipping container(s) in which they were received.
- Signs identifying the canisters as an air sample, saying “Do Not Disturb” and providing contact information. The sign should be laminated and attached to the canister with a zip tie. (These signs are for extended duration samples only because grab samples will not be left unattended.)

Alternative subslab soil vapor sampling methods:

- Bottle-Vacs:
  - Bottle-Vac(s) (evacuated, and provided by the laboratory.)
  - Flow controller set at desired sampling rate. (Flow controllers are cleaned, set, and provided by the laboratory.)
  - Digital pressure gauge with a -30 to 0-inch Hg range, and 0.50-inch Hg accuracy, which should be verified annually. This pressure gauge should have a quick-connect connection because it will be used to measure the initial and final Bottle-Vac pressure. Digital gauges should not be shared between soil vapor samples and air samples (indoor, outdoor, or crawlspace) to prevent cross-contamination.
  - T-connector (provided by the laboratory) for collecting simultaneous duplicate samples.
  - Shipping container, suitable for protection of Bottle-Vac(s) during shipping. The Bottle-Vac(s) should be shipped to the laboratory in the same shipping container(s) in which they were received.
  - Signs identifying the canisters as an air sample, saying “Do Not Disturb” and providing contact information. The sign should be laminated and attached to the canister with a zip tie. (These signs are for extended duration samples only because grab samples will not be left unattended.)

- Tedlar Bags:
  - Tedlar Bags
  - Lung box
- Sorbent Tubes:
  - Sorbent tube(s) (provided by the laboratory. Include one extra to use for flow calibration purposes.
  - SKC flow calibrator 5 to 500 mL/min to measure the exact flow rate while sampling

Procedures and Guidelines

This FOP describes the general guidelines for purging and water dam leak testing Vapor Pins, then collecting subslab soil vapor samples using evacuated canisters. Purging, leak testing, and sampling information should be recorded in the field logbook and on the attached form "Subslab Soil Vapor Sampling Log."

System Setup:

1. Wait at least 2 hours after probe installation is complete before collecting subslab soil vapor samples to allow the subsurface to equilibrate.
2. Remove the secure cover and the white cap on the Vapor Pin.
3. Attach a new piece of flex tubing, approximately 1 inch long, to the barbed fitting at the top of the Vapor Pin. Then attach 0.25-inch Teflon tubing to the flex tubing.
4. Place the water dam over the subslab probe by threading the Teflon tubing through the hole of the water dam. Press the water dam down so it seals on the concrete slab using VOC-free modeling clay. Fill with water. The water level should be above the connection between the flex tubing and the Teflon tubing.
5. Attach the other end of the Teflon tubing to the sampling manifold using a Swagelok nut and ferrule set.
6. Attach the vacuum pump to the sampling manifold using Teflon tubing and Swagelok nut and ferrule sets.
7. System set up for canister sampling:

   7.1. Measure the initial canister pressure with the digital pressure gauge. The initial pressure should be between -28 to -30 inches Hg. If it is less than -26 inches Hg do not use the canister for sampling. If it is between -28 to -26 inches Hg only use the canister if there are no other spare canisters available. In the field log record the canister identification (ID), flow controller ID, initial vacuum, desired flow rate, sample location information, and all other information pertinent to the sampling effort.

   7.2. Connect the flow controller and analog pressure gauge to the canister. When the flow controller and pressure gauge are attached correctly they will not move separately from the canister (they will not spin around).

   7.3. Connect the canister via the flow controller to the sampling manifold.

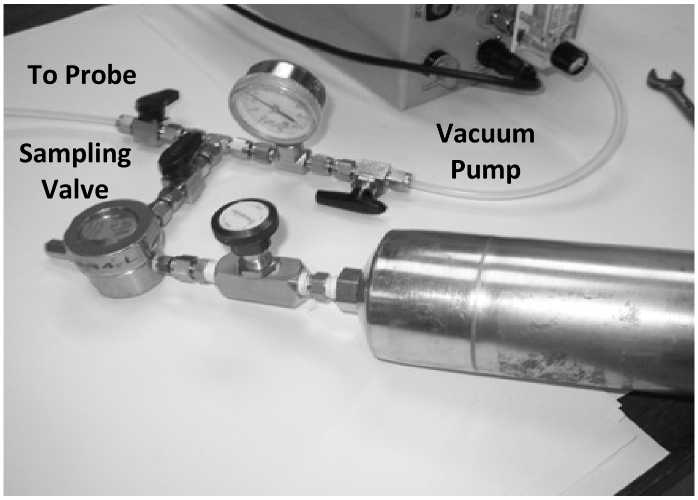

Figure 1. Sampling Manifold Setup for Canister Sampling

Manifold Vacuum Leak Check:

1. The purpose of the manifold leak test is to make sure the connections in the sampling train are air tight.
2. For canister sampling, the connections on the sampling manifold through the flow controller to the valve on the canister will be leak tested (Figure 1); for duplicate samples the whole assembly with the T-connector should be vacuum leak tested. For alternative sampling methods, the connections on the sampling manifold will be leak tested.
3. Close the valve to the probe, open the valve to the pump. For canister sampling open the sampling valve to the canister on the manifold; the valve on the canister is closed.
4. Turn the pump on and wait for the gauge on the manifold to approximately -10 inches Hg. Close the valve to the pump and turn the pump off. The sampling train is now a closed system.
5. Wait approximately 30 seconds to ensure that the vacuum is maintained and there are no leaks (as shown by the stability of the pressure gauge).
6. If there is a visible loss of vacuum, tighten the connections and redo the leak test until it passes.

Purge and Water Dam Leak-Check

1. Purging and leak testing the soil vapor probe is required before sampling every time. Purging removes ambient air from the sampling train and stagnant soil vapor around the probe.
2. Open the valves to the pump and probe, and attach the Tedlar bag to the pump effluent. The sampling valve should be closed.
3. Turn the pump on with the flowrate at 200 mL/min and purge for approximately 5 minutes to fill the 1-liter Tedlar bag.
4. Monitor the purging vacuum on the sampling manifold pressure gauge. The purging vacuum should not exceed -7 inches Hg; if it does, turn the pump off, close the valve to the pump, and wait to see if there is recovery.
    4.1. The probe may be clogged or there may be water or tight soils present beneath the slab that do not allow for soil vapor sampling.
    4.2. Try unclogging the probe with a thin metal rod, or remove the probe and check for blockages.
    4.3. If purging cannot be completed without creating a vacuum exceeding -7 inches Hg, then the probe cannot be sampled.

5. Observe the water level in the water dam for indications that water is entering the subslab (drop in water level or bubbles). If there is, the Vapor Pin failed the leak check and corrective action is required. The leak test must be performed again after corrective actions are taken until the Vapor Pin passes the leak test. Note: Water level might drop slightly because of absorption into the concrete.
6. There are five corrective action options (first remove the water from the water dam with a turkey baster):
    - 6.1. Remove the Vapor Pin, clean out the drilled hole thoroughly, replace the silicone sleeve with a new one, and reinstall.
    - 6.2. Fill in visible concrete cracks inside the drilled hole with quick-setting cement and, after allowing the cement to cure, retest.
    - 6.3. Try fortifying the Vapor Pin seal by adding modeling clay to the base of the Vapor Pin. This temporary repair is only acceptable if grab samples will be collected; permanent repairs must be made for extended duration samples (for example, 8- or 24-hour) because the clay may dry and crack.
    - 6.4. Add Teflon tape to the barbed connector and the Teflon tubing, reattach the flex tubing and the Teflon tubing, make sure that all the fittings are tight and repeat the purge and leak-check procedure.
    - 6.5. If the previous options fail, then the Vapor Pin should be abandoned.
7. Optional - Field readings of total VOCs with a PID, and/or oxygen, carbon dioxide, and methane with a LandTec GEM Landfill Gas meter may be performed on the purged soil vapor. Perform readings outside of the building so that soil vapor is not released into indoor air.
8. Record the purge and leak-check information on the Subslab Soil Vapor Sampling Log.

Canister Sampling:

1. For extended duration samples (for example, 8- or 24-hour)
    - 1.1. Remove the sampling manifold by detaching the canister from the manifold, then detaching the probe tubing from the manifold and quickly attaching it to the canister via the flow controller.
    - 1.2. Attach the sign (identifying the canisters as an air sample, saying “Do Not Disturb” and providing contact information) to the canister.
    - 1.3. Make sure the canister will be secure at the sampling location; place traffic cones around the probe and canister if necessary.
2. To begin sampling, open the canister valve one full turn and record the sample start time. (For grab samples the canister will still be attached to the sampling manifold.)
3. Monitor the canister pressure on the analog gauge (if present) several times during the sample period to ensure the canister is filling at the desired rate and the final canister pressure does not fall to 0-inch Hg.
4. At the end of the sample period, close the canister valve and record the sample end time. Detach the canister from the manifold or probe tubing.
5. Measure the final canister pressure with the digital pressure gauge. The final pressure should be between -10 to -2 inches Hg. If it is 0-inch Hg, do not submit the sample for analysis. If it is

between -2 and 0 inches Hg, re-deploy the sample if possible; if not, submit it to the laboratory for analysis but make sure it is received with some residual negative pressure.

6. Replace the protective cap on the canister.
7. Duplicate samples should be collected simultaneously with a dedicated T-connector.
    7.1. Grab sample duplicates should be collected by attaching the T-connector to each canister and then connecting one flow controller to the top of the T-connector. (If there was a flow controller on each canister, then the sampling flow rate would exceed the maximum allowable flow rate of 200 mL/min.) The duplicate sample will take twice as long to collect.
    7.2. Extended duration samples should be collected by attaching a flow controller to each canister and then connecting the T-connector to each flow controller. (If only one flow controller was used, then the sampling duration would be twice as long.)

Bottle-Vac Sampling:

1. Measure the initial pressure with the digital pressure gauge. The initial pressure should be between -28 to -30 inches Hg. If it is less than -26 inches Hg, do not use the Bottle-Vac for sampling. If it is between -28 to -26 inches Hg, only use the Bottle-Vac if there are no other spares available. In the field log, record the Bottle-Vac ID, flow controller ID, initial vacuum, desired flow rate, sample location information, and all other information pertinent to the sampling effort.
2. For extended duration samples (for example, 8- or 24-hour)
    2.1. Remove the sampling manifold and attach the probe tubing to the flow controller.
    2.2. Attach the sign (identifying the canisters as an air sample, saying “Do Not Disturb” and providing contact information) to the canister.
    2.3. Make sure the canister will be secure at the sampling location; place traffic cones around the probe and canister if necessary.
3. For grab samples – Attach the flow controller to the sampling valve on the sampling manifold.
4. To begin sampling, attach the Bottle-Vac to the to the flow controller via the quick-connect and record the sample start time.
5. At the end of the sample period, detach the Bottle-Vac from the flow controller and record the sample end time. Detach the flow controller from the probe tubing or sampling manifold.
6. Measure the final Bottle-Vac pressure with the digital pressure gauge. The final pressure should be between -10 to -2 inches Hg. If it is 0-inch Hg, do not submit the sample for analysis. If it is between -2 and 0-inch Hg, redeploy the sample if possible; if not submit it to the laboratory for analysis but make sure it is received with some residual negative pressure.
7. Duplicate samples should be collected simultaneously with a dedicated T-connector as described in the Canister Sampling section.

Tedlar Bag Sampling:

1. Detach the vacuum pump from the sampling manifold and attach it to the lung box, then attach the probe tubing via the sampling manifold to the lung box influent.
2. Place a Tedlar bag in the lung box using dedicated Teflon and flexible silicon tubing.
3. To begin sampling, turn the pump on and record the sample start time.

4. Turn the pump off when the Tedlar bag is full and record the sample end time. The Tedlar bag should only be filled 50 percent if it will be shipped via plane.
5. Detach the probe tubing and vacuum pump from the lung box.

Sorbent Tube Sampling:

1. Disconnect the pump tubing from the manifold.
2. Attach a spare sorbent tube provided by the laboratory to the vacuum pump tubing using a 1/4-inch Swagelok union or flex tubing. Do not use a tube that is intended for sampling. Be sure to attach the sorbent tube so that the flow direction is correct.
3. Attach the SKC flow calibrator to the vacuum pump exhaust.
4. Turn on the vacuum pump and adjust the flow to achieve the desired flow rate of 200 mL/min using the flow calibrator.
5. Remove the spare sorbent tube from the pump tubing.
6. Remove the end caps from the sorbent tube to be used for sampling and attach it to the vacuum pump tubing using a 1/4-inch Swagelok union or flex tubing. Be sure to attach the sorbent tube so that the flow direction is correct. Record the sample tube ID on the field form.
7. Attach the other end of the sorbent tube to the sample manifold where the pump tubing used to be attached using either Swagelok fittings or flex tubing.
8. Make sure both the probe valve and the vacuum pump valve are open and the sampling valve is closed.
9. Start the pump and record the start time. Using flow calibrator, record initial flow rate.
10. If the flow rate starts to drop, it may indicate that the sorbent tube is becoming plugged with water. Stop the vacuum pump and record the end time.
11. After the required amount of time, record the final flow rate from the flow calibrator. Turn off the pump and remove the sorbent tube. Record the end time.
12. Replace the end caps on the sorbent tube. Replace the sorbent tube into the container it was received in.

After Sample Collection is Completed:

1. Disassemble the sampling system and replace the white silicone cap on the Vapor Pin.
2. For permanent probes - replace the black plastic or stainless steel secure cover and make sure it is securely in place.
3. Fill out all appropriate documentation (chain-of-custody and sample tags) and return samples and equipment to the laboratory in the same shipping container in which they were received. Do not place sticky labels or tape on surface of the canister.
4. Canisters, Bottle-Vacs, and Tedlar bags should not be cooled during shipment. DO NOT put ice in the shipping container. Sorbent tubes may require ice for shipping.

Quality Control and Quality Assurance

- Verify no less than 2 hours between probe installation and collecting subslab soil vapor samples.

- Canisters supplied by the laboratory must follow the performance criteria and quality assurance prescribed in U.S. Environmental Protection Agency (EPA) Method TO-14/15 for canister cleaning, certification of cleanliness, and leak checking.
- Flow controllers supplied by the laboratory must follow the performance criteria and quality assurance prescribed in EPA Method TO-14/15 for flow controller cleaning and adjustment.
- Field duplicates and trip blanks (sorbent tube methods only) may be required. Check the work plan for frequency.

Attachments

- Subslab Soil Vapor Sampling Log
- Sign identifying the canisters or Bottle-Vacs as an air sample, saying “Do Not Disturb” and providing contact information.

References

U.S. Environmental Protection Agency. Office of Solid Waste and Emergency Response. 2015. *Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air*. June.

Cox-Colvin & Associates, Inc. (Cox-Colvin). 2016. *Standard Operating Procedure – Installation and Extraction of the Vapor Pin*. September.

Subslab Soil Vapor Sampling Log

Project:

Sampler:

Sample Location Information

Property ID/Address:

Condition of slab in the surrounding area:

Location ID: Sample ID:

Sample Location Description (Room Name/Number and surrounding, identifying features):

Subslab Soil Vapor Probe Leak Checking and Sampling Log

Manifold Leak Check

Manifold leak check (procedure: ensure manifold holds pressure at -10 "Hg for 30 seconds). If using a pelican-case pump, open the lid during leak check to ensure all interior pieces are in-tact.	*Pass*	*Fail*

Describe corrective measures taken to pass the manifold leak test:

Subslab Soil Vapor Probe Water Dam Leak Check and Purge Results

Purge rate (mL/Min):

Start Time:

Purge Vacuum ("Hg):

End Time:

Probe Leak Check Result*:	*Pass*	*Fail*

*The subslab soil vapor probe passes the water dam leak check if there are no bubbles observed and the water level does not draw down during purge. Do NOT collect a subslab soil vapor sample if the leak check fails.

Field Analysis (required readings are determined on a project-specific basis. Fill in all that are necessary):

MiniRAE or MultiRAE Photoionization Detector

Total VOCs (ppm): O_2 (%):

H_2S (ppm): LEL (%):

CO (ppm):

LandTec GEM Landfill Gas Meter

O2 (%):

CO2 (%):

CH4 (%):

Sampling Information

Evacuated Canister or Bottle-Vac

Container Size (L): Initial Pressure (" Hg):

Container ID: Start Date and Time:

Flow Controller ID: End Date and Time:

Sampling Rate (mL/min, hours): Final Pressure (" Hg):

Sampling Vacuum ("Hg):

Tedlar Bag

Tedlar Bag size (L): Start Date and Time:

Sampling Rate (mL/min): End Date and Time:

Sorbent Tube

Sorbent Tube type and size: Start Date and Time:

Sorbent Tube ID: End Date and Time:

Initial Flow Rate (mL/min): Final Flow Rate (mL/min)

Calculated Sampling Volume:

Weather Conditions and Additional Notes

Weather Conditions During Sampling:

Additional Notes:

Field Operating Procedure
Indoor, Outdoor, and Crawlspace Air Sampling Using Canisters

Prepared by: Jennifer Simms **07/07/2017** Jen Simms

Author

Reviewed by: Brett Fishwild **date**

Site Manager

Approved by: Kimberly Amley **07/07/2017** Kimberly Amley

Program Quality Manager

Indoor, Outdoor, and Crawlspace Air Sampling Using Canisters

Purpose

This Field Operating Procedure (FOP) presents general guidelines for collecting indoor, outdoor, and crawlspace air samples using evacuated canisters. The type, number, location, and sample duration of indoor, outdoor, and/or crawlspace air samples should be determined on a project-specific basis. A building survey should be performed before air sampling to obtain building characteristic information and identify potential confounding indoor sources of volatile organic compounds.

Scope

This FOP provides a general description of how to collect indoor air, outdoor air, and crawlspace air samples using evacuated canisters.

Equipment and Materials

- Stainless-steel sampling canister(s), certified clean and evacuated (canisters are cleaned, evacuated, and provided by the laboratory). Note that separate canisters of the same size may be designated by the laboratory for use in collecting subslab soil vapor samples versus indoor air, outdoor air, and crawlspace air samples and may been certified in different manners. It is important to make sure that canisters are used for their designated sample type.
- Flow controller(s), certified clean, and set at desired sampling rate (flow controllers are cleaned, set, and provided by the laboratory).
- Analog pressure gauge dedicated to the canister may be permanently attached to either the canister or flow controller. This pressure gauge will be used to monitor the canister pressure during sampling.
- Digital pressure gauge with a -30 to 0-inch mercury (Hg) range, and 0.50-inch Hg accuracy, which should be verified annually. This pressure gauge should have a Swagelok 1/4-inch female connection because it will be used to measure the initial and final canister pressure. Digital gauges should not be shared between air samples (indoor, outdoor, or crawlspace) and soil vapor samples to prevent cross-contamination.
- Wrenches and screwdriver, various sizes as needed for connecting fittings. A 9/16-inch wrench fits the 0.25-inch Swagelok fittings, which most canisters and flow controllers have.
- For crawlspace air sampling:
  - Sampling probe, new Teflon tubing, fitted with compression fittings (for crawlspace air samples).
  - Swagelok nut and ferrule set (part #SS-400-NFSET) to connect tubing to the canister.
  - Rod for placing the crawlspace air sampling tubing or the canister at the desired location in the crawlspace. These can be metal, plastic, or wooden rods.

- T-connector (provided by the laboratory) for collecting simultaneous duplicate samples. This is optional for indoor and outdoor air samples, but may be necessary for crawlspace air samples if the canisters are not being placed into the crawlspace.
- For outdoor air samples:
  - Sampling cane or aluminum foil tent to prevent water from entering canister during sampling.
  - Bike lock or chain and lock to secure the canister and prevent theft.
- Shipping container, suitable for protection of canister(s) during shipping. Typically, strong cardboard boxes are used for canister shipment. The canisters should be shipped to the laboratory in the same shipping container(s) in which they were received.
- Signs identifying the canisters as an air sample, saying "Do Not Disturb" and providing contact information. The sign should be laminated and attached to the canister with a zip tie. (These signs are for extended duration samples only because grab samples will not be left unattended.)

Procedures and Guidelines

This FOP describes the general guidelines for collecting indoor, outdoor, and crawl space air samples using evacuated canisters. Sampling information should be recorded in the field logbook and on the attached form "Indoor, Outdoor, and Crawlspace Air Sampling Log—Canister Method."

- Measure the initial canister pressure with the digital pressure gauge. The initial pressure should be between -28 to -30 inches Hg. If it is less than -26 inches Hg, do not use the canister for sampling. If it is between -28 to -26 inches Hg, then only use the canister if there are no other spare canisters available. In the field log, record the canister identification (ID), flow controller ID, initial vacuum, desired flow rate, sample location information, and all other information pertinent to the sampling effort.
- Connect the flow controller and analog pressure gauge to the canister (**Figure 1**). When the flow controller and pressure gauge are attached correctly, they will not move separately from the canister (they will not spin around).

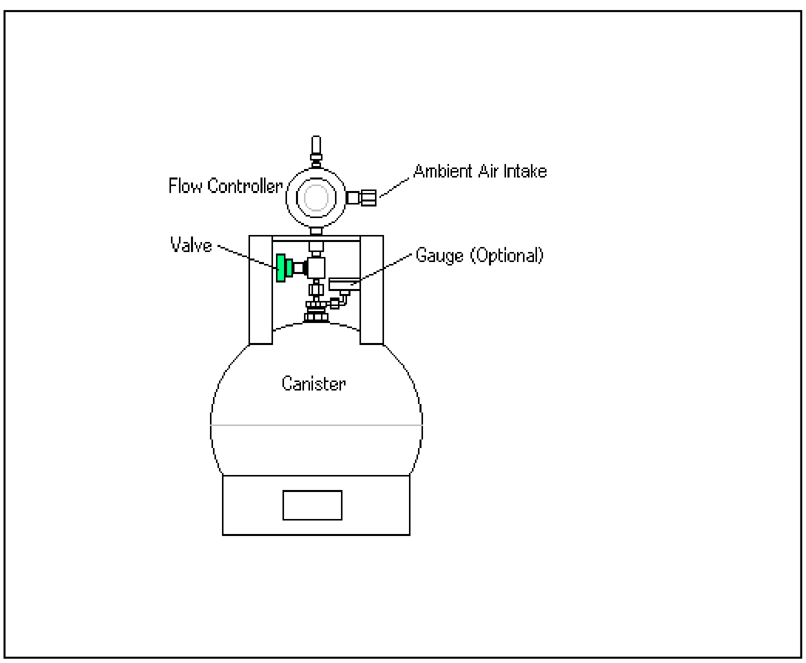

Figure 1. Assembled Canister Sampler for Integrated Sample Collection

- For outdoor samples, be sure that the inlet to the flow controller is protected from precipitation. Either place the canister and flow controller under a shelter/enclosure, use a sampling cane provided by the laboratory, or use a clean piece of aluminum foil to build a tent over the flow controller inlet. Secure the canister to an immovable structure with the bike lock or chain and lock to prevent theft.
- For sampling crawlspace air through Teflon tubing, adjust the length of the sample tubing to be able to reach the desired sampling location, attach it to the rod with tape or zip ties, and place the sampling probe into the crawlspace using the rod. Make sure the sample tubing influent is several inches above the ground level. Now connect the sample tubing to the inlet of the flow controller.
- For sampling crawlspace air by placing the canister in the crawlspace, use a rod to position the canister in the correct location.
- For indoor air samples, place the canister in the desired sampling location. Indoor air samples are typically collected at breathing zone height (3 to 5 feet above the floor).
- Attach the sign (identifying the canisters as an air sample, saying “Do Not Disturb” and providing contact information) to the canister.
- To begin sampling, open the canister valve one full turn and record the sample start time.
- Monitor the canister pressure several times during the sample period to ensure the canister is filling at the desired rate and the final canister pressure does not fall to 0-inch Hg.
- At the end of the sample period, close the canister valve and record the sample end time.
- Measure the final canister pressure with the digital pressure gauge. The final pressure should be between -10 to -2 inches Hg. If it is 0-inch Hg, do not submit the sample for analysis. If it is between -2 and 0-inch Hg, redeploy the sample if possible; if not, submit it to the laboratory for analysis but make sure it is received with some residual negative pressure.
- Replace the protective cap on the canister.
- Fill out the appropriate documentation (chain of custody, sample tags) and return canisters and equipment to the laboratory in the same shipping container in which they were received.
- The samples should not be cooled during shipment. DO NOT put ice in the shipping container.
- Do not place sticky labels or tape on any surface of the canister.

Quality Control and Quality Assurance

- Canisters supplied by the laboratory must follow the performance criteria and quality assurance prescribed in U.S. Environmental Protection Agency (EPA) Method TO-14/15 for canister cleaning, certification of cleanliness, and leak checking.
- Flow controllers supplied by the laboratory must follow the performance criteria and quality assurance prescribed in EPA Method TO-14/15 for flow controller cleaning and adjustment.

Attachments

- Indoor, Outdoor, and Crawlspace Air Sampling Log—Canister Method
- Sign identifying the canisters as an air sample, saying “Do Not Disturb” and providing contact information.

References

U.S. Environmental Protection Agency. Office of Solid Waste and Emergency Response. 2015. *Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air.* June.

Indoor, Outdoor, Crawlspace Air Sampling Log - Canister Method

Project: ______________________________

Building: ______________________________

Field Sample ID	Location	Canister ID	Flow Controller ID	Initial Pressure ("Hg)	Start Date	Start Time	Check (6/20 hr)		End Date	End Time	Final Pressure ("Hg)
							Time	Pressure ("Hg)			

Weather Conditions

General weather conditions: ______________________________

____

Temperature Range (indoor and outdoor): ______________________________

Was there significant precipitation within 12 hours prior to (or during) the sampling event? ______________________________

Air Testing in Progress

Please Do Not Disturb

Contact for Further Information:

Name: ____________________________

Organization:_____________________

Phone:____________________________

Field Operating Procedure Sample Handling and Chain-of-Custody

Prepared by: Jennifer Simms **08/25/2017**

Author

Reviewed by: Brett Fishwild **date**

Site Manager

Approved by: Kimberly Amley **9/13/2017**

Project Quality Manager

Sample Handling and Chain-of-Custody

Purpose

This Field Operating Procedure (FOP) defines “custody” and describe protocols for documenting the transfer of custody from one party to the next (for example, from the site to the laboratory). A documented custody trail is established using sample tags and a U.S. Environmental Protection Agency (EPA) chain-of-custody form that uniquely identifies each sample container, and who has possession of it from the sample’s origin to its destination. The chain-of-custody form also describes the sampling point, date, time, and analysis parameters.

Scope

This is a general description of how to document the transfer of custody of samples from one party to the next. Sample personnel should be aware that a sample is considered n a person’s custody if the sample meets the following conditions:

- It is in a person’s actual possession
- It is in view after being in a person’s possession
- It is locked up so that no one can tamper with it after it has been in physical custody

When samples leave the custody of the sampler, the cooler must be custody-sealed and possession must be documented.

Data generated from the use of this FOP may be used to support the following activities: site characterization, risk assessment, and evaluation of remedial alternatives.

Equipment and Materials

- Computer with Scribe software loaded
- Laser printer with paper (8.5- × 11-inch) and ink cartridge (black)
- EPA Region 5 Sample Tag
- Scribe generated tag label (adhesive labels)
- Indelible black ink pen
- Bubble wrap
- 2-gallon resealable plastic bags for ice
- Packing/strapping tape
- Custody seals

Procedures and Guidelines

Chain-of-Custody Forms

The chain-of-custody form (see Attachment 1 for example) must contain the following information:

- Case Number/Client Number: If a Contract Laboratory Program (CLP) laboratory is used, enter the case number provided by EPA’s Regional Sample Control Center Coordinator. If the CLP is not used, enter the SAS number provided by CH2M HILL, Inc’s (CH2M’s) sample and analytical coordinator.

- EPA Region: Enter Region “5”.

- Site Name/State: Enter the site name and state.
- Project Leader: Enter the CH2M site manager's name.
- Action: "Remedial Investigation."
- Sampling Co.: "CH2M HILL"
- Sample No.: This is the unique number that will be used for sample tracking. For CLP, this number is taken from a block of numbers assigned by the EPA Regional Sample Control Center Coordinator. For non-CLP, the CH2M sample and analytical coordinator will assign the number.
- Matrix: Describes the sample media (for example, "Sediment").
- Sampler Name: The name of the sampler or sample team leader.
- Concentration: Low (L), Low/Medium (M) or High (H).
- Sample type: "Grab" or "Composite."
- Analysis: This indicates the analyses required for each sample.
- Tag No.: This number appears on the bottom of the sample tag and includes a prefix ("5") followed by a series of numbers. The entire number must appear on the chain-of-custody form.
- Preservative: Document what preservative has been added to the sample (for example, "HCl," "Ice Only," "None").
- Station Location: This is the CH2M Station Location Identifier.
- Sample Collect Date/Time: Use military time.
- QC Type: This is for field quality control (QC) only, and includes field duplicates.
- Date shipped: The date that samples are relinquished to the shipping carrier.
- Carrier Name: (for example, "FedEx").
- Airbill: Air bill number used for shipping.
- Shipped to: This is the laboratory name and full address, including the laboratory contact. If the contact is not known, use "Sample Custodian".
- Chain-of-Custody Record fields: The sampler's signature must appear in the "Relinquished By" field. The date and time (military time) must also be included.
- Although the samples are "relinquished" to the shipping carrier, the shipping carrier does not have access to the samples if the shipping cooler is custody sealed. Consequently, the shipping carrier does not sign the chain-of-custody form.
- Sample(s) to be used for laboratory QC: This identifies which samples are to be used for matrix spike/matrix spike duplicate analyses.
- Indicate if shipment for case is complete: USE "Y" OR "N".
- Chain-of-Custody Seal Number: Record the custody seal numbers that appear on the Region 5 custody seals that can be found on the shipping container. There is usually a minimum of two per shipping container.

1.1.1 Sample Tags

Each sample container will be identified with a uniquely numbered sample tag (see Attachment 1 for example) issued by EPA Region 5. Each tag will contain the following information:

- Case/SAS number
- The unique sample number for sample tracking
- CH2M HILL station location (that is, the sample identifier)
- Date of sampling
- Time the sample was collected (in military time)
- All parameters for which the sample will be analyzed
- Preservative used (if any)
- Sample type (grab or composite)
- Sample concentration (low, medium, high)
- Sample matrix (such as soil)
- The signature of sample team leader
- Identification when sample is intended to be used by the laboratory for matrix spike/matrix spike duplicate (if applicable)

Quality Control and Quality Assurance

1. All sample containers must be properly tagged.
2. Each cooler/box (canisters only) must have a chain-of-custody form, and the samples in the cooler/box (summa canisters only) must match what is on the chain-of-custody form (as identified by the sample tags).
3. Each chain-of-custody form must be properly relinquished (signature, date, time).
4. The custody seal numbers must be written on each chain-of-custody form.
5. The shipping cooler/box (canisters only) must be custody sealed in two places: front and back.
6. Chain-of-custody forms will be completed with required sampling information, and recorded information will match the sample tags.
7. If the designated sampler relinquishes samples to other sampling or field crew members for packing or other purposes, the sampler will complete the chain-of-custody form prior to this transfer.
8. Appropriate personnel will sign and date chain-of-custody forms to document the sample custody transfer.
9. Original chain-of-custody forms will be placed in resealable plastic bags and will accompany the shipment; copies will be retained by the sampler for sampling records.
10. If samples are sent by common carrier, bills of lading will be used. Receipts or bills of lading will be retained as part of the permanent project documentation.
11. Commercial carriers will not be required to sign off on chain-of-custody forms if the forms are sealed inside the sample cooler and the custody seals remain intact.

12. Packaging, marking, labeling, and shipping of samples will comply with the regulations promulgated by the U.S. Department of Transportation in the *Code of Federal Regulations* (49 CFR 171-177).

Attachments

Attachment 1: Quick Guide to Using Scribe

References

None.

Field Operating Procedure
Packing and Shipping of Environmental Samples

Prepared by: Jennifer Simms **08/25/2017**

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Reviewed by: Brett Fishwild **date**

Site Manager

Approved by: Kimberly Amley **9/13/2017**

Kimberly Amley

Project Quality Manager

Packing and Shipping of Environmental Samples

Purpose

This Field Operating Procedure (FOP) presents general guidelines for the packing and shipping of samples to the laboratory for analysis.

Scope

This is a general description of how to pack and ship samples collected and prepared for analysis at an offsite laboratory

Equipment and Materials

- Waterproof hard plastic coolers
- Resealable plastic bags
- Plastic garbage bags
- Absorbent packing material (not vermiculite)
- Inert cushioning material (not vermiculite)
- Ice
- U.S. Environmental Protection Agency (EPA) Region 5 sample tags
- Scribe software
- Laptop and printer
- Adhesive labels (generated by Scribe software)
- Chain-of-custody forms (generated by Scribe software)
- EPA Region 5 custody seals
- Air bills and shipping pouches (or example, FedEx)
- Clear tape
- Strapping tape
- Mailing labels

Procedures and Guidelines

Prepare Sample Bottles for Shipment

1. Arrange sample containers in groups by sample number.
2. Check that sample container lids are tight.
3. Secure appropriate EPA Region 5 sample tags around lids of sample container with string or wire.
4. Arrange containers on ice in assigned coolers.
5. Affix appropriate adhesive labels to each container.
6. Enclose each sample in a clear, resealable plastic bag, making sure that sample labels are visible.

Prepare Evacuated Canisters Shipment

1. Arrange sample canisters in groups by sample number.
2. Check that the canisters were fully closed upon completion of sampling.
3. Secure appropriate EPA Region 5 sample tags around canister with string or wire.
4. Arrange canisters in assigned boxes for shipment. Note that canisters are not shipped with ice.
5. Place flow controllers used for sampling within the box for shipment.
6. Affix appropriate adhesive labels to each box.

Prepare Coolers or Boxes (Evacuated Canisters only) for Shipment

1. Tape drains shut, inside and out.
2. Affix "This Side UP" labels on all four sides and "Fragile" labels on at least two sides of each package being shipped).
3. Place mailing label with laboratory address on top of each package.
4. Place inert cushioning material (for example, bubble wrap, preformed poly-foam liner) in the bottom of each package. Do not use vermiculite.
5. Place appropriate chain-of-custody records with corresponding custody seals on top of each package.
6. Double-bag and seal loose ice in resealable, plastic, zip-top bags to prevent melting ice from leaking and soaking the packing material. Place the ice outside the garbage bags containing the samples. Place sufficient ice in cooler to maintain the internal temperature at 4±2 degrees Celsius during transport. Evacuated canisters are not shipped on ice.
7. Put an absorbent pad in the bottom of the cooler and fill the cooler with enough packing material to prevent breakage of the sample bottles and to absorb the entire volume of the liquid being shipped (offsite sample shipment only). Absorbent material is not required for shipment of evacuated canisters.
8. Record the EPA Region 5 custody seals on the chain-of-custody forms. Sign each chain-of-custody form (or obtain signature) and indicate the time and date the cooler was custody sealed.
9. Seal the laboratory copies of the chain-of-custody forms in a large resealable plastic bag and tape to the inside lid of the package. Retain the Region 5 copies of the chain-of-custody forms for return to EPA. Each cooler must contain a chain-of-custody form (or forms) that corresponds to the contents of the package.
10. Close lid and latch.
11. Peel custody seals carefully from backings and place intact over lid openings (right front and left back). Cover seals with clear protection tape. When shipping evacuated canisters, verify that custody seals are placed so that if the box was opened they would break.
12. Tape package shut on both ends, making several complete revolutions with strapping tape. **Do not** cover custody seals.
13. Relinquish to carrier (for example, Federal Express). Place air bill receipt inside the mailing envelope and send to sample documentation coordinator, along with the other documentation.

Quality Control and Quality Assurance

None.

Attachments

None.

References

None.

Field Operating Procedure
Note Taking and Field Logbook

Prepared by: Jennifer Simms **08/25/2017**

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Note Taking and Field Logbook

Purpose

This Field Operating Procedures (FOP) presents general guidelines for recording field and sampling information in a field logbook.

Scope

This is a general description of how to record field and sampling information in a field logbook to support site characterization, risk assessment, and evaluation of remedial alternatives.

Equipment and Materials

- Field logbook
- Indelible black ink pen
- Write-in-the-rain pen (for extreme weather conditions—cold/rain)

Procedures and Guidelines

All information pertinent to a field or sampling effort will be recorded in a bound field logbook that will be initiated at the start of the first onsite activity. The field logbook will consist of a bound notebook with consecutively numbered pages that cannot be removed. The outside front cover of the logbook will contain the project (site) name and the specific activity (for example, supplemental remedial investigation). The inside front cover will include the following:

- Site name and U.S. Environmental Protection Agency work assignment number
- Project number
- Site manager's name and mailing address
- Sequential logbook number
- Start date and end date of logbook

Each page will be consecutively numbered, dated, and initialed. All entries will be made in indelible black ink, and all corrections will consist of line-out deletions that are initialed and dated. If only part of a page is used, the remainder of the page should have an "X" drawn across it. At a minimum, entries in the logbook will include the following:

- Time of arrival and departure of site personnel, site visitors, and equipment
- Instrument calibration information, including make, model, and serial number of the equipment calibrated
- Description of significant activities for the day
- Documentation of photographs taken during field activities (for example, date, time, and description of photograph)
- Field observations (for example, sample description, weather, unusual site conditions or observations, and sources of potential contamination)
- Detailed description of the sampling location, including a sketch when necessary

- Details of the sample site (for example, coordinates [*x*, *y*], water elevation [*z*], casing diameter and depth, and integrity of the casing)
- Sampling methodology and matrix, including distinction between grab and composite samples
- Names of field team members and subcontractors
- Start or completion time of sample collection activities
- Field measurements (for example, water depths and sediment probe depths)
- Type of sample (for example, sediment, groundwater, surface water, soil, and debris)
- Number, depth, and volume of sample collected
- Field sample number
- Requested analytical determinations
- Sample preservation
- Quality control samples associated with the sample
- Sample shipment information including chain-of-custody form number and laboratory, carrier, date, and time
- Health and safety issues (including level of personal protective equipment)
- Signature and date by personnel responsible for observations

Sampling situations vary widely. No general rules can specify the extent of information that must be entered in a logbook. However, records should contain sufficient information so that someone can reconstruct the sampling activity without relying on the collector's memory. The field team leader will keep a master list of all field logbooks assigned to the sampling crew.

Quality Control and Quality Assurance

- The field notes will be reviewed by the field quality manager at the end of each work day performed.

Attachments

None.

References

None.

Appendix B
Laboratory Standard Operating Procedures

To be provided upon laboratory procurement